JOURNAL OF THE

SMPTE

597 Black Level—The Lost Ingredient in Television Picture Fidelity • *R. G. Neuhauser*

602 Television Line Structure Suppression • *Francis T. Thompson*

607 Printing Motion-Picture Films Immersed in Liquid

Part I: Contact Printing • *John G. Stott, George E. Cummins and Henri E. Breton*

Part II: Optical Printing • *John R. Turner, Duane E. Grant and Henri E. Breton*

616 Data-Recording Xenon Flashlamp • *Edward A. Colson and Harold E. Edgerton*

618 Portable Power Supply for High-Speed Cameras • *Donald H. Peterson and Niel G. Currie*

622 A Simple Schlieren System for Two Simultaneous Views of a Gas Flow • *George Rudinger and Lowell M. Somers*

623 Effect of Gate and Shutter Characteristics on Screen Image Quality • *Willy Borberg*

627 Letter to the Editor—Projector Light Sources • *John S. Carroll*

628 Early Projector Mechanisms • *Don G. Malkames*

83d SMPTE Convention • April 21–26 • Ambassador Hotel, Los Angeles

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Black Level—The Lost Ingredient in Television-Picture Fidelity

By R. G. NEUHAUSER

This paper outlines TV-system improvements instituted in recent years which produce and maintain the ability to reproduce proper black level (or d-c restoration) in the television receiver. The necessity for proper black-level control in the production of TV pictures having good fidelity is discussed, and factors which caused its importance to be minimized in the past are noted. Specific equipment and instrumentation advances which have resulted partly from the advent of color television are also described. The entire TV system, from the studio to the receiver, is considered. A suggested waveform standard that can be used to achieve day-to-day and station-to-station uniformity of black-level reproduction is illustrated.

FINAL PICTURE quality as viewed on a home television receiver is a product of the performance factors of the entire TV system, transmitting station, network and receiver, and not any one part. Since the earliest days of television broadcasting, individual broadcasters and networks have demanded improvements in tubes and equipment which would enable them to transmit better television pictures. They have not only adopted improved devices as rapidly as they have become available, but have on their own endeavored to improve the quality of their pictures by development of better camera-operation, exposure and lighting techniques, and better studio, control-room and programming practices. Standards for these techniques and practices do exist and are maintained. Unfortunately, there is no standard or even agreement among stations or networks as to the television signal component that determines proper black-level setting except for color transmissions for which FCC has set rather rigid standards.*

Circuitry for "black-level setting" (as it is termed in the sense of picture reproduction) or "d-c restoration" (as it is commonly called in electrical terms) is, generally, no longer included in the television-receiver portion of the TV system. This type of circuitry was one of the first casualties in the program of cost reduction undertaken to bring the price of television sets to a level that would fit into the budget of almost every American family. At the time d-c restoration was dropped from receiver design, this step was taken with a good deal of justification, as explained later under the section on Limitations of Early Equipment.

Effective arguments for the inclusion of black-level-setting circuitry in TV systems have been presented by several eminent authorities in the field of television engineering. Zworykin[1] and Wendt,[2] for example, have described its importance from the overall system standpoint, while Birkinshaw[3] has made an eloquent plea for the inclusion of black-level-setting circuitry in receivers.

When a black-level setter is not used in a receiver, the picture-tube bias is set to provide a pleasing picture having both good blacks and whites and the intermediate tones of gray on an average television signal.

Unfortunately, there is no such thing as a constant average signal, i.e. one having peak whites and peak blacks balanced uniformly about the average information of a video signal. Consequently, on a television receiver, a mood shot, such as a romantic moonlight walk, looks like an overexposed picture taken by an amateur with a box camera on a cloudy day. Bright outdoor scenes look rather dingy and all gray tones of the low-light portions are clipped off. The dramatic effect of a fade-out is lost in a "fog-out," as the screen turns white instead of dark.

On the TV studio monitor, however, these dramatic and artistic effects are realistic and approach those so carefully achieved and maintained in the motion-picture industry. One need only spend a few hours in a television studio watching a monitor (on which the directors watch and establish the picture quality and moods which, of course, have proper black-level setting) to realize that when he sees the picture on his own receiver, he is badly cheated.

Figures 1 and 2 show the effects of improper black-level setting on different types of TV pictures. Figures 1A and 1B are low-key scenes displayed on a picture tube having proper black-level setup, and in Figs. 1C and 1D is shown the lack of contrast and the loss of the desired artistic effect which results when black-level control is omitted. Figures 2C and 2D show the effect of black-level clipping when the overall scene is predominantly white. In Figs. 2A and 2B black level is set at the proper point; in Figs 2C and 2D, proper black level is not maintained on the picture tube.

System Requirements for Proper Black-Level Control

The accuracy of reproduction of the black level in a TV picture is dependent upon two considerations: (1) the ability of the signal generator to deliver an electrical signal containing accurate

Presented on May 2, 1957, at the Society's Convention at Washington, D.C., by R. G. Neuhauser, Electron Tube Div., Radio Corp. of America, Lancaster, Pa.
(This paper was received on June 3, 1957.)

*Since the FCC specifies no value of black level setup for monochrome transmission (see Fig. 3), station-to-station practice varies considerably on this item. It has been brought to our attention by R. N. Harmon that a new proposed IRE standard (57 IRE 23.PS1) of TV signal measurement is being formulated. This will specify a value of setup for both monochrome and color broadcast.

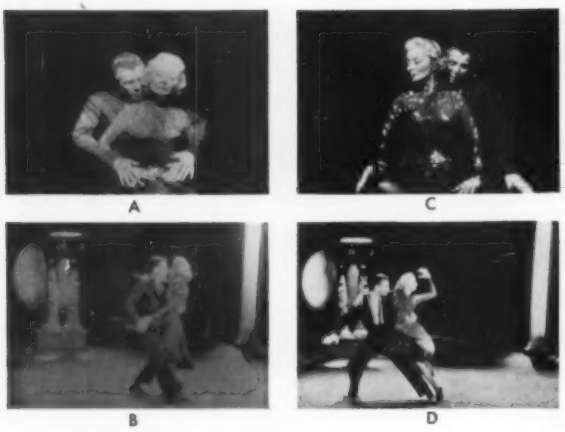

Fig. 1. A and B are illustrative of proper black-level setting. C and D show loss of contrast on low-key scenes resulting from improper black-level setting.

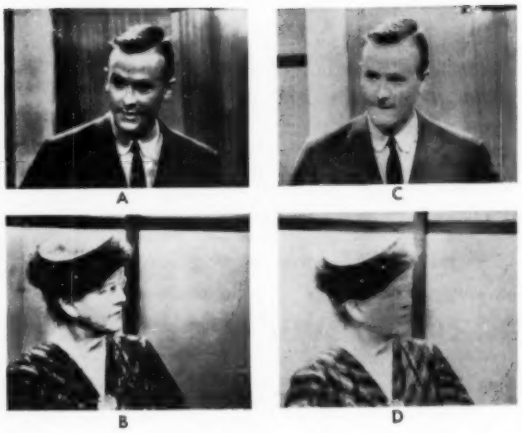

Fig. 2. A and B are pictures with proper black-level setting. C and D show the clipping of black level on bright pictures, due to improper black-level setting.

black information, and (2) the ability of the system to maintain accurately a specified synchronizing and blanking (or black-level setup) amplitude.

Figure 3 shows the composite signal including the video signal and the synchronizing signals. To establish black level properly, the TV receiver requires definite information from the TV signal. Since the signal during the picture interval varies randomly in a time-amplitude sense, the receiver circuits must respond to information conveyed during the blanking interval. This implies that the information presented to the receiver during this interval must be constant and dependable.

The problem resolves itself to the shape and relative amplitudes of the signal components during this interval. The shape and timing of the signal during this interval are specified in FCC standards for the television signals. The most important factor, the amplitude of these components of the video signal, is not rigidly specified in these standards. To assure that the retrace lines are cut off, the black level of the video signal as shown in Fig. 3 should be set at a fixed relative amplitude above the blanking level. It would be very easy to use the blanking level for determining kinescope bias for proper black-level setting, except for the fact that this portion of the signal is cluttered by the synchronizing signal. Consequently, the receiver must either derive its information during the relatively short "back-," or "front-porch," portions of the blanking signal, or operate on the peak amplitude of the synchronizing signal.

The first method requires very accurate timing (and it is further complicated by the fact that the color television color-burst signal now occupies the larger back porch); and the second requires that the amplitudes of both the black-level setup and synchronizing signal be constant and set to a prescribed industry standard level. If such is the case, setting the kinescope grid at a fixed voltage during the synchronizing interval allows brightness adjustments to be made so that information intended to be black, appears just black, and stays there.

The TV system must, therefore, be capable of generating a TV signal having tight tolerances on the amplitude during the blanking interval, and be capable of maintaining these amplitudes without distortion throughout the entire system. If these requirements are not met, it is completely unfair and unrealistic to expect a receiver (even one equipped with properly designed d-c restoration circuits) to produce pictures having proper tone rendition and black level.

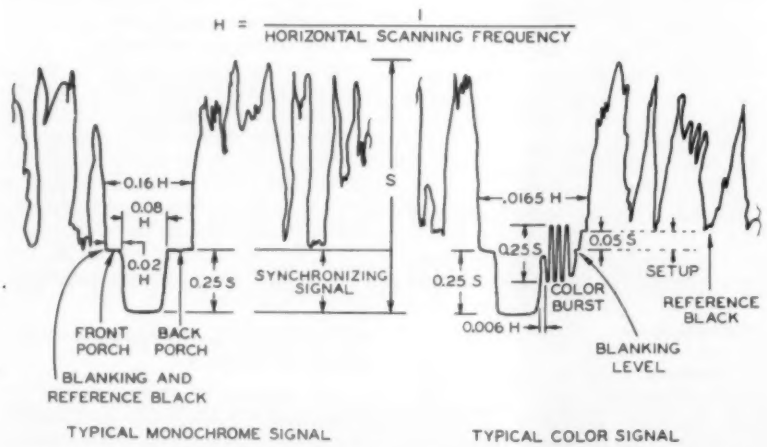

Fig. 3. Composite television signal including the video signal and the synchronizing signal.

Limitations of Early Equipment

Early camera tubes (iconoscopes and early image orthicons) were incapable of automatically generating signals containing proper black-level information: the former because of their inherent characteristics, the latter because the necessary manufacturing controls and proper operating techniques for image orthicons had not been developed. Early camera preamplifiers, video amplifiers, and processing amplifiers did not, in general, have the linearity of amplification (differential gain characteristics) necessary to maintain black-level information and, furthermore, the clamping circuits used with these amplifiers were not fully developed. To transmit black-level information, it was necessary for the operator to monitor the camera output signal continuously, recognize black-level information, and instantly make the necessary changes in the outgoing signal by manual adjustment. The operator's problems in this respect were complicated not only by the fact that he had numerous other duties to perform, but also because early equipment for measuring the overall amplitude

of a video signal or the relative amplitudes of its components was, at best, crude and inaccurate. The establishment of black level in the TV signal was dependent entirely upon the skill, judgment and agility of the operator. These difficulties existed not only in the equipment used by individual broadcasters, but also in network and leased video-transmission facilities.

In addition, the modulator circuits of early television transmitters were extremely nonlinear, particularly in the peak-signal regions which contain the blanking and synchronizing signals from which the receiver might derive black-level information. Considering all these shortcomings, and the natural lack of experienced personnel in a new and rapidly growing industry, it is not surprising that there was no uniformity of black level between signals from different stations or even in those from a particular station.

Early television receivers also contributed problems. Although these receivers were equipped with circuits for black-level setting (d-c restoration), they had shortcomings which generally prevented proper utilization by these circuits of any black-level information which might be present in the incoming signals. Among these shortcomings were low-gain, high-noise amplifier and converter stages which permitted noise to interfere with the operation of circuits for d-c restoration, especially on the weak signals from distant stations upon which many television viewers depended. Another shortcoming was lack of automatic gain control or, at best, inadequate automatic-gain-control systems, with the result that there were substantial differences in signal level at the d-c restorer when the receiver was tuned from station to station.

Considering all of these errors, probable, inherent and actual, it is no wonder that black-level setting was abandoned in receiver design. Once done, a "so what" attitude developed for a time throughout the entire system in regard to maintaining black levels in the video signals. Today, there is no more justification for this attitude from the broadcaster's viewpoint, than for chiseling on frequency response of audio channels because many radio receivers have only a 3-in. speaker.

Recent System Improvements

Perhaps the biggest factor that has effected a change in these conditions has been the advent of *color*. No portion of the TV system has escaped change for the better in the modifications and system "clean-ups" that were necessary for proper generation, transmission and display of color-television pictures.

TV Signal-Generation Devices. The TV camera tube or flying-spot camera, the generator of the video-signal information, is the first portion of the system. If the signal generated here is inaccurate in its black-level information or content, any further attempt to restore or control black level is wasted effort.

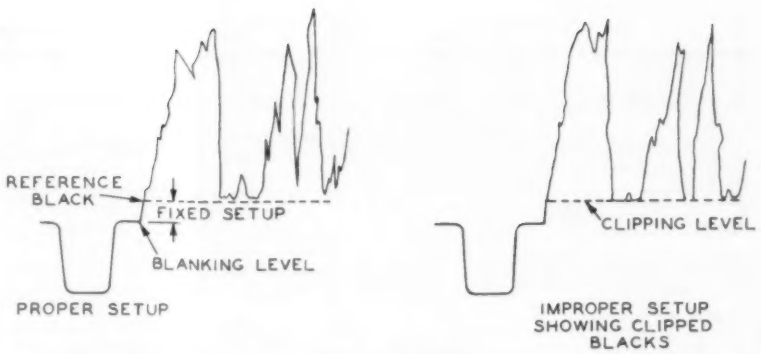

Fig. 4. Illustration of the use of the "fixed-setup" feature of television processing amplifiers.

A great deal of effort has been applied successfully to achieve basic improvements of these devices in the past few years. The image orthicon, the mainstay of TV studios, can, when properly operated, produce a video signal having a fixed and accurate black level. The image orthicon can tolerate much abuse in its setup and exposure and still present a usable picture. However, its signal may lack good black-level information if the tube is not properly exposed, or if it is operated so that the bulk of the light of the image does not fall on the linear portion of the tube's transfer characteristic.

These facts have been forcibly brought home by experience in color camera-tube operation. When these tubes are used in color cameras, exact black-level control and accurate tone rendition are vital for the reproduction of proper colors, since the signals from the three camera tubes must track and be unaffected by redistribution of secondary electrons. Therefore, strict attention must be paid to proper exposure of image-orthicon tubes to assure accurate black-level control.[4]

The benefits of this experience are indicated by the fact that tone rendition of color programs on black-and-white receivers is noticeably superior to that of black-and-white programs. There has also been some improvement in the black-level performance of film cameras using iconoscopes (which have inherently poor black-level reproduction). This improvement has resulted from the development of low-noise amplifiers which permit substantial reductions in iconoscope beam current, and thereby make it possible to achieve more accurate gray-scale rendition and some degree of black-level stability. Iconoscope cameras, however, are rapidly being replaced by superior film-pickup equipment employing either vidicon pickup tubes or flying-spot scanners, both of which have excellent black-level stability and gray-scale rendition.

Camera-System Video Amplifiers. The video amplifiers and preamplifiers used in television cameras and studios ever since early days have generally had excellent frequency-response and phase characteristics up to 8 mc and, therefore, have required little improvement in this respect. The linearity or differential gain characteristics of these amplifiers, which determine their ability to transmit black-level information without distortion, have, however, been substantially improved. To a large degree, these improvements have been necessitated by the advent of color. Improved linearity has been achieved principally by liberal use of feedback throughout camera, switching and distribution gear, and particularly in the output stages of the amplifiers which feed the coaxial cables connecting the various system components. As a result, linearity of amplification is more than adequate for proper maintenance of black level.

In the middle of the video-amplifier system of a studio or camera system is the all-important signal processing amplifier. In this amplifier, the video signal is cleaned up: the microphonic pickup, deflection transients and a-c hum are eliminated, and black-level information in the video signal is detected and set to a predetermined level. All of this "magic" is performed by the clamping and clipping circuits, probably the most important circuits of the television-camera system. In these circuits, the blanking and synchronizing signals are combined with the video signal to form the composite television signal. In this process, amplitude relationships between black level, the video blanking level, sync and overall signal are established and controlled. It is not desirable to have all of these values variable, because the video operator whose job it is to control these factors would find it too much to cope with. Sync amplitude level, therefore, is usually fixed, and only black-

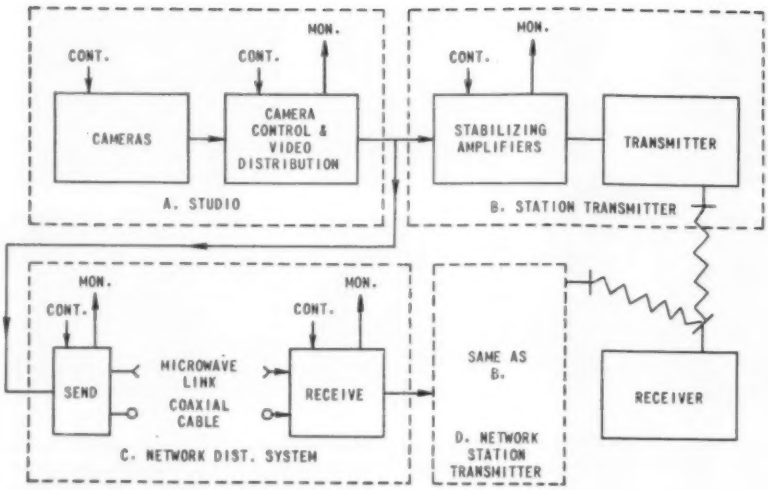

Fig. 5. Block diagram of the entire TV system.

level "setup" above blanking and video amplitudes are the variables under his control. This is a particularly critical control point and requires that the video operator be on his toes.

Since the operator usually has other duties, a device to aid him is incorporated in most broadcast-type signal processing amplifiers. This device, known as a "fixed-setup control," adds a fixed amount of blanking to the video signal (or, if you will, to the sync signal), and can be preset to provide the standard blanking level which for color is 5% of peak-to-peak signal amplitude. Although the presetting feature does not relieve the operator of the responsibility of setting black level, it does free him from the necessity of measuring and recalibrating the setup continually. He merely sets the blacks just above the level at which they would be clipped off (Fig. 4). He can then very easily produce and maintain a proper black-level setting in outgoing signals and maintain the black-level match between two or more camera signals.

Numerous improvements have also been made in clamp circuits. Improved timing control and time-constant control, for example, prevent clamping on spurious signals or deflection transients which may be present in the video signal, and provide a high degree of immunity from clamping on noise signals.

For remote pickups or network tie-ins, the practice is to synchronize the local synchronizing generator with the incoming signal. The video signal is then fed to a stabilizing amplifier, where the original synchronizing signals are clipped off and replaced by the well-formed local signals. This amplifier is essentially a refinement of the processing amplifier previously described, and has been improved in a similar manner.

Transmitters. Television transmitters are normally nonlinear, especially in the peak-signal regions which contain the synchronizing, blanking and black-level information. This nonlinearity varies in both type and degree from transmitter to transmitter, and can be a particularly troublesome source of black-level errors. Here, too, color has forced improvements, particularly to minimize distortion of the color-burst signal which sits on the back porch of the blanking signal and extends fairly far down toward the peak of the synchronizing signal. To assure linear amplification of color-burst signals, however, not the transmitter but the video signal is altered. A nonlinear amplifier designed to compensate exactly for the nonlinearity of the transmitter is inserted in the video line to the transmitter modulator. Thus, full peak power and linear amplification of the video signal are obtained without extensive and expensive modification of the transmitter.

Transmission Facilities. The quality of the intercity and intracity circuits provided by the telephone company for transmission of network TV programs has also been substantially improved. Practically all TV network circuits are now capable of relaying color-television signals back and forth across the country with negligible degradation. In other words, the differential gain characteristics and freedom from clipping action of every amplifier in the system are now more than adequate to preserve those portions of the television signal which convey black-level information. The signal is clamped at the receiving end of the distribution system to eliminate power-line interference and pickup, and delivered to the network stations in very good condition, free from distortion and unwanted signals. Operating and maintenance standards are very high, and are continually being refined.

Instrumentation. It is well and good to say that conditions are such that good black level can be set and maintained. It is another thing to say whether it is maintained. The often quoted adage, "If you can't measure it, you don't know a thing about it," is particularly true of a TV signal. At the originating point, it is necessary to determine and control the level of sync and adjust the black-level setup and video amplifier gain in proper relationship to the synchronizing signal. Furthermore, to assure proper transmitter modulation or transmission-line amplitude, the overall signal amplitude must be maintained at a constant level. The means of observing and calibrating the video signal is an oscilloscope. Attempts to calibrate this signal on an ordinary scope with varying video scene content, causing the peaks of the signals to vary about the d-c axis, is like trying to read while riding horseback and in the process trying to make accurate adjustments akin to threading a needle. Fortunately, special oscilloscopes are now available which clamp the synchronizing signal to a reference line on the scope screen and permit direct comparison of signal-output levels with calibration pulses of known amplitude.

Also available are flat-face oscilloscope tubes which improve accuracy of calibration by reducing parallax errors. Another recent refinement is the line-selector oscilloscope. This oscilloscope allows the operator to observe a selected line or pair of lines of the television raster and provides an extremely stable, clean trace which permits control of signal variables to accuracies of 1 or 2%.

Figure 5 is a block diagram of the TV system showing control and monitoring points.

Comparative Systems

The foregoing discussion has, it is hoped, demonstrated that our present TV system has the facilities necessary to establish and maintain proper black level in television signals. The fact that the necessary facilities are available, however, does not guarantee results any more than ownership of a piano makes one a musician. For black-level control each station should employ proper setup and operating procedures, and the broadcast industry as a whole should adopt standards for synchronizing amplitude and amplitude of black-level setup. Perhaps the simplest solution to this problem, from the broadcasters' viewpoint, would be for all stations to adhere to the FCC standards for color (except, of course, those applying to color burst and subcarrier) for black-and-white transmissions.

From an engineering standpoint, we can hope that the broadcasters and networks will be patient and continue to maintain and improve the standards and practices that they have so ably

developed and that the climate will eventually be such that adequate d-c restoration will again become universally employed in the design of both color and black-and-white television receivers.

Of course, proper black-level setting in a receiver cannot be achieved by merely inserting a diode in the video amplifier. It is also necessary to have good automatic gain control to maintain proper signal level, and linear amplification. The lessons learned in color TV receiver design have again shown how these factors can be achieved at a minimum cost.

It is encouraging, therefore, to see that several American receiver manufacturers are again including d-c restoration in their receivers, although they have not, thus far, advertised the fact or attempted to educate the public to the resulting benefits. Their neglect in this respect is regrettable, because the public has shown that it appreciates fidelity in sound reproduction and should be even more appreciative of fidelity in television pictures.

A concerted effort on the part of the station, network and transmission-facilities operating personnel to demonstrate the practicability of good black-level transmission is needed to convince those who would benefit from it that good black level is here to stay and can be capitalized upon for the good of both the equipment producer and the consuming public.

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Discussion

Ralph B. Harmon (*Westinghouse Broadcasting Co., New York*): I would certainly agree that the whole system must maintain setup very accurately. I know when we tried this on our own stations, we were able to have fairly good control over the setup of our own signals as we originated them on several cameras at the stations. We immediately got a great hue and cry from our audience when we went to the network, because the setup that was coming to us off the network was variable and they most frequently had a minimum of setup if any at all. If we were in a network program and the receiver had been adjusted so that the average brightness was acceptable to the viewer, and we then went to our local origination with the 5% setup or whatever we call standard then the picture at the home was no good. Everybody has to get into the act and keep the setup constant, otherwise it isn't going to pay off.

Mr. Neuhauser: I agree completely. The requirement at the present time is for some standards to be adopted. I think the point of my talk is that these standards can be maintained because the equipment has been modified, changed and improved to the point where it can be done. You can measure it and you can count on it.

Television Line Structure Suppression

By FRANCIS T. THOMPSON

Experiments indicate that television viewers select a viewing distance at which the line structure begins to disappear. If the line structure is destroyed, the preferred viewing distance is reduced to about 60%. Other advantages and the disadvantages of eliminating the line structure are discussed. Several methods of eliminating it are described. The results of an experimental comparison of television pictures with and without structure suppression are given. A photographic comparison is also given.

IT HAS BEEN reported[1] that the most popular vertical viewing angle for movies is approximately 17° while that for television is 8°. Previous data[2] which were verified by experiments described in this paper indicate that the average eye is just able to resolve lines which subtend one minute of arc at the eye. This value of one minute of arc is equivalent to a vertical viewing angle of 7.8° for a picture composed of 480 active lines.

Experiments indicate that television viewers tend to select a viewing angle at which the line structure just begins to disappear. Under these circumstances it is easy to see one reason why the trend toward larger television pictures has declined. The average living room cannot easily provide the minimum 10½-ft viewing distance desired for 24-in. receivers.

It would be desirable to suppress or eliminate the line structure in television pictures thereby allowing the larger receivers to be comfortably viewed at reduced distances. Experiments indicate that the same viewers who chose 8° vertical viewing angles for a conventional picture prefer 10° to 16° angles for a reduced structure television picture.

Presented on April 30, 1957, at the Society's Convention at Washington, D.C., by Francis T. Thompson, Westinghouse Research Laboratories, Westinghouse Electric Corp., Pittsburgh 35, Pa. (This paper was received on April 30, 1957.)

Fundamental Considerations

There are several methods of reducing the appearance of line structure in television pictures. Each must accomplish the same basic task, that of filling in the dark spaces between the scanning lines with information which does not contrast with the scanning lines.

The desired result may be obtained by increasing the vertical dimension of the scanning spot. The effect of the vertical spot dimension on vertical resolution is illustrated in Fig. 1. In (a) of Fig. 1 the spot height is less than the line pitch which is normal in larger size picture tubes. The black space between the scanning lines is distracting. In (b) the vertical spot dimension is equal to the line pitch and represents the maximum spot dimension at which full vertical resolution is retained. In (c) the spot dimension is greater than the line pitch resulting in beam overlapping and a consequent loss of vertical resolution. The most desirable is (b) from the point of view of maximum structure suppression.

Methods of Enlarging the Effective Vertical Spot Dimension

The vertical spot dimension may be enlarged by defocusing the electron spot; however, defocusing also enlarges the horizontal spot dimension resulting in a serious loss of horizontal resolution. The effect of increasing the horizontal spot dimension, which is similar to increasing the aperture of a pinhole camera, is illustrated in Fig. 2. The center of the electron spot produces the desired sharp transition but the overlapping of the outer portions results in a gradual change in brightness. Spot defocusing is not a practical method because of the loss in horizontal resolution.

The ideal electron beam spot from the standpoint of structure suppression and resolution has an effective vertical dimension equal to the line pitch and a very small horizontal dimension. Such a spot is difficult to obtain by electron optics and once obtained is particularly difficult to maintain as the beam is deflected over the face of the tube.

One possible solution to this problem lies in the use of a lenticular plastic screen which is placed against the front of the picture tube.[3] This screen provides a finer line structure by optically superimposing the light from adjacent lines. Superimposing light from several lines results in a loss of small area contrast, however, and thereby decreases the sharpness of the picture. Figure 3 shows a portion of a television picture in which the line structure is very obvious. The structure is reduced by the lenticular screen as shown in Fig. 4.

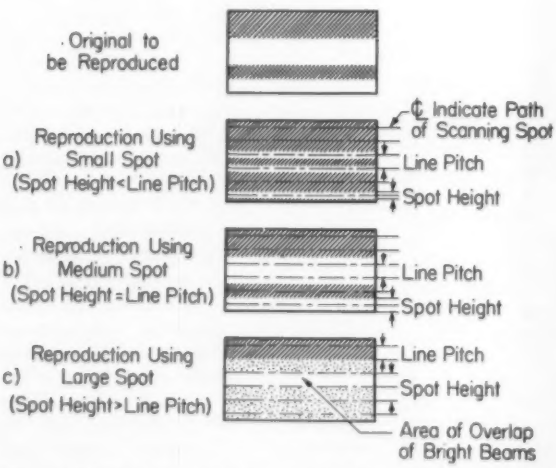

Fig. 1. Effect of vertical electron spot dimension on vertical resolution.

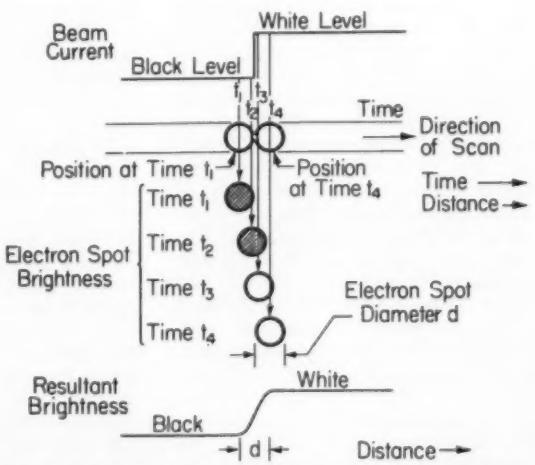

Fig. 2. Effect of horizontal spot diameter on horizontal resolution.

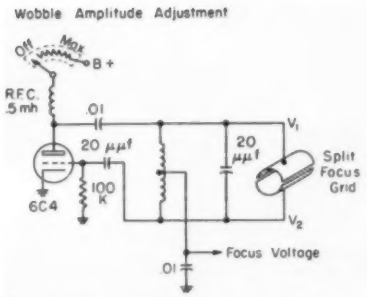

Fig. 5. Spot-wobble oscillator circuit.

The small horizontal spot dimension of a well-focused spot may be retained if the effective vertical spot dimension is enlarged by adding a low-amplitude high-frequency vertical deflection to the existing sawtooth deflection at the receiver. The frequency can always be made high enough so that the individual cycles of the vertical deflection are not visible. The amplitude of this deflection is adjusted so that the scans of adjacent lines are tangent as in Fig. 1(b).

This technique which is known as spot wobble is used commercially in England to compensate for their coarser line structure.[4–6] The English 405-line system exhibits the same line structure on a 21-in. receiver as our 525-line system does on a 27-in. receiver. In the British system a free-running oscillator with small auxiliary vertical deflection coils as part of the resonant tank was used to wobble the spot. Each coil consisted of a few turns of wire wound on the neck of the picture tube.

A free-running oscillator and auxiliary coil combination has several disadvantages:

1. The low Q of the auxiliary coils necessitates a high driving power and results in an increase in the amplitude of harmonics which may produce interference in the receiver.

2. It is difficult to resonate auxiliary deflection coils at frequencies above 10 mc. The wobble pattern is quite noticeable at lower frequencies.

3. Difficulty has been experienced from voltage breakdown between the auxiliary coils and conventional deflection yoke.

Improved Spot Wobbler

The problems associated with electromagnetic spot wobble may be eliminated if an electrostatic system is used. Eros Atti and James A. Hall of the Westinghouse Electronic Tube Div. have developed a special TV picture tube which contains a split cylindrical focus grid. The electron beam may be deflected vertically if a potential difference is applied between the halves of the split grid. The application of this tube to spot wobble was suggested by the author.

The capacitance between the split grid elements, which is only a few micromicrofarads, may be made a part of the tuned circuit of a high-frequency oscillator as illustrated in Fig. 5.

This arrangement has several advantages:

1. The oscillator-split grid combination results in a high Q which minimizes driving power and reduces oscillator harmonics.

2. High frequencies can be obtained easily because of the low capacity of the split grid.

3. The production cost of splitting the focus electrode is small when compared with the cost of auxiliary deflection coils.

Photographic Results

Photographs were taken using a 21-in. receiver equipped with a split grid focus tube. A picture transmitted by a 245-line, 2.5-mc bandwidth, 60-field/sec, two-to-one vertical interlace system was displayed on a 12 by 16-in. area of this tube. The line structure is equivalent to displaying a conventional 525-line picture on a 36-in. picture tube. The amplitude of the 25-mc wobble was adjusted by varying the d-c oscillator supply voltage. The wobble amplitude was adjusted until the scanning lines were tangent and a photograph was taken. The oscillator was turned off and a conventional line scan picture was photographed. No other adjustments were made. The results are shown in Figs. 6 through 11.

The lines are much less apparent in Figs. 7, 9 and 11. The lines in Figs. 6, 8 and 10 spoil the continuity of the pictures and tend to mask high-detail information if the picture is viewed too closely. Reducing the apparent structure allows the viewer to enjoy the detail and to sit closer to the screen. Although the pictures contain the same amount of detail, some viewers stated that the wobble picture appeared to contain more detail than the conventional-scan picture.

The vertical resolution of the test patterns of Figs. 10 and 11 is low as seen in the horizontal wedges, because of the 245-line raster. The horizontal resolution is higher than would be expected with a 2.5-mc bandwidth because of the 136-μ second horizontal period. A comparison of the conventional scan of Fig. 10 with wobble scan of Fig. 11 shows that the resolution is not noticeably degraded by the addition of spot wobble.

Subjective Experiments

A. 245-Line Picture

Fifty observers individually viewed the conventional and the spot-wobble pictures of Figs. 6 and 7 on the 21-in. receiver. They were asked to view the set closely and then move back to a distance where they could comfortably view the picture. The number of observers sitting closer than a given distance is plotted in Fig. 12 for the conventional and spot-wobble pictures. The variation in vision was eliminated by taking the ratio or the viewing distance for the spot-wobble picture to the viewing distance for the conventional picture. The distance ratios were grouped and plotted in Fig. 13.

This experiment indicates that the viewing distance for larger receivers is determined by the line structure rather than the picture detail.

B. 525-Line Raster

A group of fifty viewers was used to determine the distance from a 24-in. receiver at which the line structure becomes barely resolvable. The test was conducted using a standard 525-line television raster with no video modulation at a brightness of 20 ft-L. The viewers backed away from the receiver until the lines just blended together. Distances were recorded for the conventional raster and the wobbled raster using a 13.2-mc wobble deflection voltage. The number of observers sitting closer than a given distance is plotted in Fig. 14 for the conventional and spot-wobble raster. The ratio of the viewing distance for the spot-wobble raster to the conventional raster is plotted in Fig. 15.

The average viewing distance for the conventional raster, 10.6 ft, corresponds to a vertical viewing angle of 7.6°. This result is close to the 7.8° value calculated from the one minute of arc resolution. The average distance for the wobbled raster, 6.1 ft, corresponds to a vertical viewing angle of 13.1°.

A further experiment was conducted using a live telecast on this same 24-in. receiver. A number of the same viewers were seated in a chair with casters and asked to move about and pick the location from which they preferred to view the receiver. When a conventional line picture was shown they chose approximately the same distance that they had selected in the previous experiment with a conventional raster. When the wobble was added they moved closer to the receiver and chose approximately the same location at which the wobbled line structure had disappeared.

This experiment indicates that the 8° viewing angle chosen by TV viewers was determined by the line structure. Viewers can be expected to choose viewing angles as large as 13° with reduced structure television. The use of these moderately larger viewing angles can be expected to increase the popularity of

Figures 3, 4 and 6–11 appear on pp. 604 and 605.

Fig. 3. Line-scan reproduction.

Fig. 4. Lenticular lens structure suppression reproduction.

Fig. 6. Line scan.

Fig. 7. Spot-wobble reproduction.

Fig. 8. Line-scan reproduction.

Fig. 9. Spot-wobble reproduction.

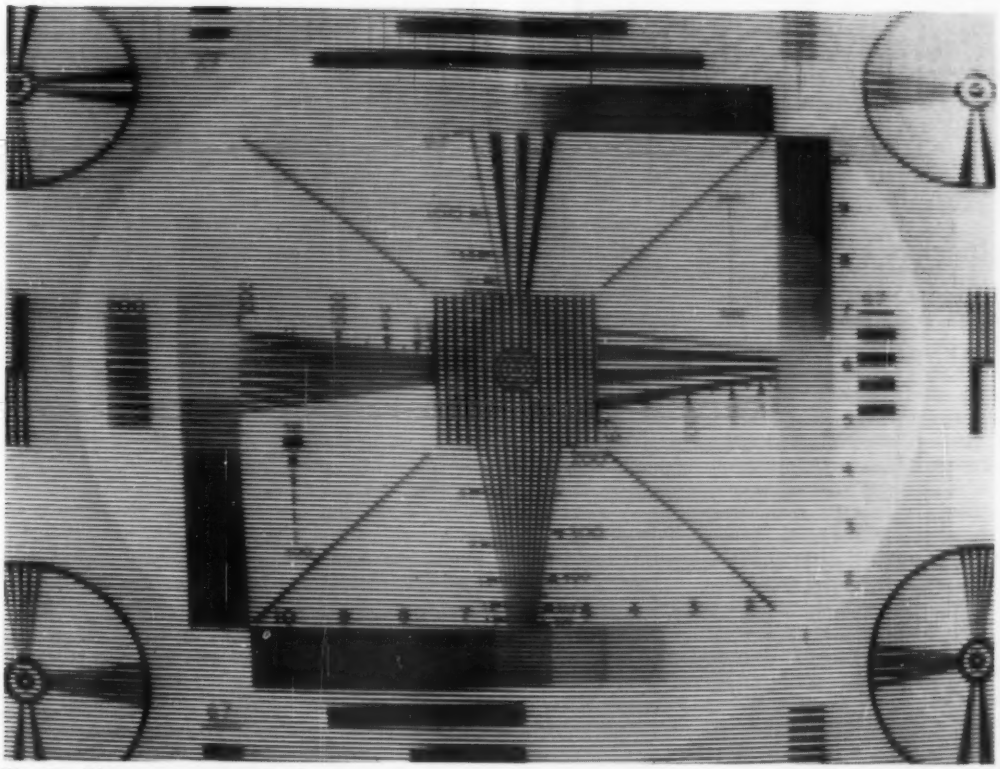

Fig. 10. Line-scan test reproduction.

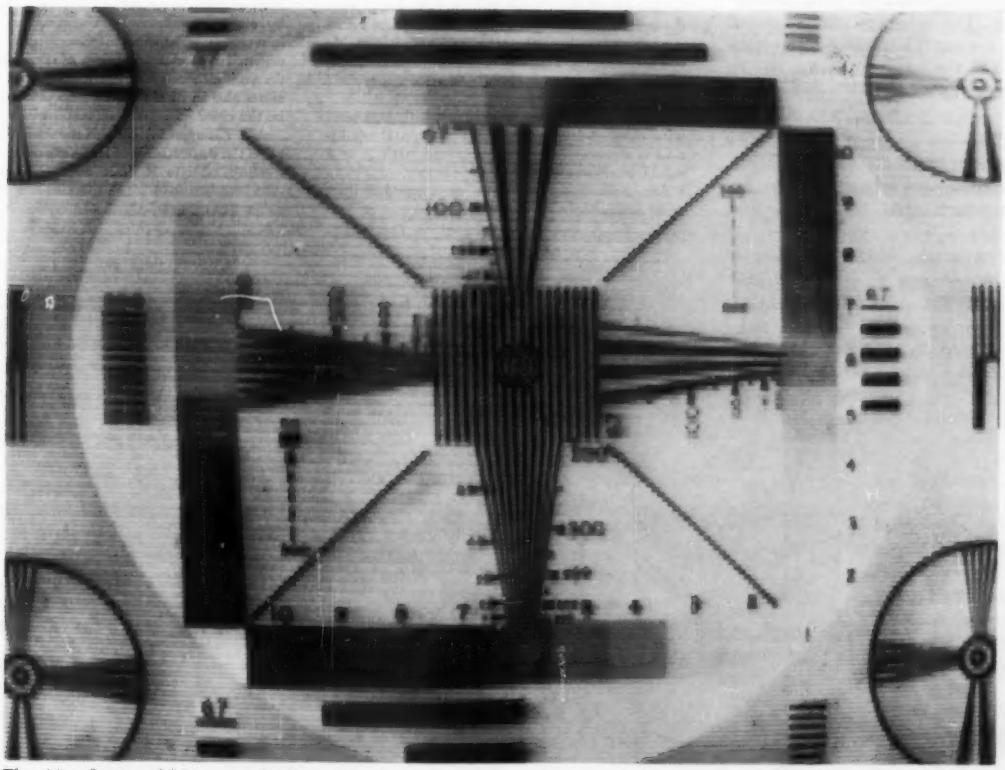

Fig. 11. Spot-wobble reproduction.

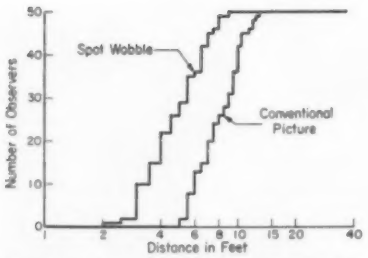

Fig. 12. Observers sitting closer than a given distance (245-line picture).

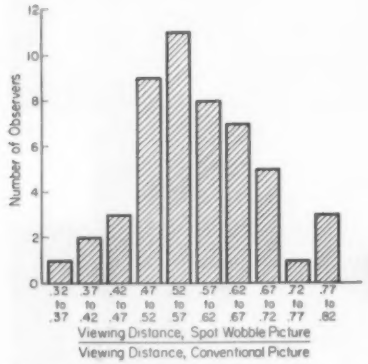

Fig. 15. Effect of spot wobble on viewing distance (525-line raster).

large-screen TV receivers since they can be comfortably viewed in the average livingroom. The inherent picture detail present in a 4-mc TV picture will probably prevent the use of viewing angles larger than 15°.

Conclusion

The results obtained using the 21-in. receiver and the conventional 24-in. receiver to which split grid guns and single tube wobbler circuits were added indicate the desirability of structure reduction.

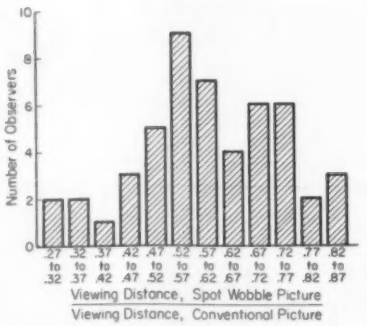

Fig. 13. Effect of spot wobble on viewing distance (245-line picture).

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3. S. I. Tourshov, U.S. Patent 2,728,013.
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5. "Television spot wobbler," *Electronics*, p. 212, July 1952.
6. British Patent 535,905.

Discussion

G. L. Beers (Radio Corp. of America): In the curves which you showed, where the people sat closer, I noticed that your test pattern indicated horizontal resolution of 400 or 500 lines. Was the system that you used in obtaining the information as to where the people would sit capable of that resolution or was it limited to something of the order of 300 or 350 lines, which is typical of standard broadcasting?

Mr. Thompson: A 2.5-mc bandwidth was used with the 245-line display. The horizontal resolution is equivalent to that obtained with 5 or 6 mc in a conventional 525-line display.

Dr. Beers: And when you used the 525 lines you just had a blank raster?

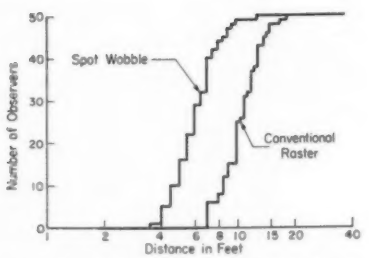

Fig. 14. Observers sitting closer than a given distance (525-line raster on 24 in.).

Mr. Thompson: That's right.

Dr. Beers: I would like to ask, then, whether with spot wobble and with the limitations of standard broadcasting, could the person who sat closer actually get any more information out of the picture than if he sat back at a distance where he could just barely recognize line structure?

Mr. Thompson: We did run an additional experiment on this 24-inch receiver using a live telecast, but the results were not accurately recorded. Approximately 20 of the 50 observers who viewed the blank raster were asked to repeat the experiment using a live telecast. When spot wobble was added they moved closer and chose approximately the same position that they had chosen in the blank raster experiment.

Dr. Beers: But you did not make any tests at all to determine whether, when you used spot wobble, they could actually see anything additional in the picture by sitting closer.

Mr. Thompson: That's correct.

F. N. Gillette (General Precision Laboratory): In working with projection equipment using spot wobble we observed one of the first improvements that the general observer picked up was that "line crawl" disappeared rather completely and rather startlingly, when the lines just merged; that is line crawl brought into existence by either movement of the observer's head or movement of objects in the scene either up or down. In your observation of direct-view tubes, do you either confirm the fact that the effect exists also in direct view or do you find it not to be the case?

Mr. Thompson: Although spot wobble does suppress the appearance of structure on still or slowly moving objects it does not eliminate vertical interlace breakup when the viewer's head or the subject moves rapidly in the vertical direction.

Printing Motion-Picture Films Immersed in a Liquid

Part I: Contact Printing

By JOHN G. STOTT, GEORGE E. CUMMINS and HENRI E. BRETON

A printing method is described that gives high quality motion-picture prints from badly scratched negatives. Both the negative and print film are completely immersed at the printing aperture in a liquid having an index of refraction close to that of gelatin and acetate support. The process nearly completely eliminates the printing effect of scratches and other surface irregularities on the negative, and improves the definition of positive prints by providing a continuous optical medium through which the exposing light passes from the negative to the print film. A step contact liquid-immersion printer and a continuous contact liquid-immersion printer are described.

One of the most troublesome problems in a motion-picture laboratory is scratches, digs, abrasions, and cinch marks (henceforth referred to as scratches) on films from which prints are made. These scratches print through to the release print and degrade the quality of the projected picture by introducing image elements that have no relationship to the original photographed scene.

Let us consider the optical mechanism by which scratches degrade the positive screened picture. A scratch on the support of a negative film acts as a secondary diffuser that scatters light as shown in Fig. 1. Light from the printer passes essentially in straight lines through the undamaged portion of the support and emulsion of the negative to the positive emulsion. When light strikes the scratch, however, it is scattered and displaced from the straight line path casting a shadow on the positive emulsion. Thus, scratches on the support of the negative appear as *white* lines on the projected positive film.

The effect of scratches on the support of negative films may be minimized on the projected print by printing with a highly diffused light source. Then, since the light reaching the support of the negative film is scattered to begin with, a scratch on the support of the negative is of less consequence. However, in black-and-white contact printing, use of a diffuse source may lead to serious loss of definition in the print if contact is not excellent. In color printing, where it is impossible to bring each of the image-bearing layers in the color negative in contact with those of the positive film because of the multilayer composition of both films, the definition of certain color elements in the picture may be degraded.

Scratches on the support of a negative film printed onto positive film usually produce more objectionable effects on the screen than scratches on reversal originals printed onto reversal print films. This is because scratches on the support of negative films appear white on the positive film, and are generally of lower density than any other white in the picture. In reversal printing, scratches on the support of the original appear black on the screen print and generally tend to blend in better with the picture.

Scratches on the emulsion side of negative films present another situation. Light emulsion scratches will appear white on the positive film. Emulsion scratches on a black-and-white negative that penetrate the emulsion to the support will print black. Scratches on the emulsion side of color negative films may appear colored on the print depending upon how deep the scratch is and whether image-bearing layers have been disturbed.

Studies outlined in this paper have all been made on negative-positive color processes, and to these we shall confine our comments.

Sources of Damage

During normal printing and handling operations in a motion-picture laboratory, original negatives and intermediate films may become damaged. This damage generally occurs as fine scratches and cinch marks originating from particles of dirt that become lodged upon the film surfaces. As the films are wound and rewound, the dirt particles trapped between convolutions of film scratch the emulsion and support if any motion occurs between the adjacent convolutions. This type of damage gradually becomes greater as more prints are made. Long, longitudinal scratches may be produced as the negative travels through a printer, passing over rollers and stationary printing apertures. However, proper design, maintenance and operation of printers can reduce this source of film damage to a minimum.

Many negative scratches come from film cleaning and rewinding where careless handling, failure to change cleaning cloths frequently, and failure to keep equipment in good repair can damage the negative out of all proportion to the number of prints made. Generally, more than 75% of all negative scratches occur on the support side of the film since during printing the part of the emulsion side that bears the picture image never comes in contact with a roller or a stationary printer aperture.

Theory of Printing Using Liquids

In 1934 Sandvik[1] described a method of reducing parasitic noise in the reproduction of film sound records by scanning the film while it is immersed in liquid.

Talbot[2] has shown how the printing effect of quite heavy scratches on the support side and light scratches on the emulsion side of negative films can be minimized by lacquering the negative. The lacquer, having an index of refraction close to that of film support and gelatin, fills the scratch and eliminates its effect as a diffuser.

Suits[3] proposed coating still-picture

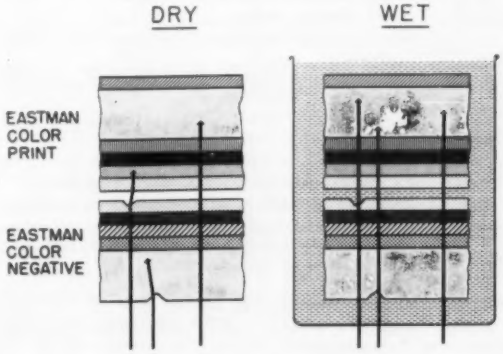

Fig. 1. (Left) Cross-section of film showing light rays being scattered by scratches in the negative. (Right) With films submerged in a liquid of proper refractive index, light rays are not scattered while passing through the negative owing to continuous optical medium.

Presented on May 1, 1957, at the Society's Convention at Washington, D. C., by John G. Stott (who read the paper), George E. Cummins and Henri E. Breton, Color Technology Div., Eastman Kodak Co., Kodak Park Works, Rochester 4, N. Y.

(This paper was received on July 30, 1957.)

negatives with a silicone liquid, which he named Refractasil,* in order to minimize the effect of negative scratches on enlarged prints. When a liquid having an index of refraction close to that of film support and gelatin is coated on the emulsion and support sides of the negative film, or when both the negative and print films are totally submerged in the liquid during printing, the liquid fills in the scratches and eliminates their effect (Fig. 1).

Furthermore, the use of liquids for contact printing should improve the definition of the release prints. If excellent contact between negative and print is achieved, as for example by the use of compressed air at the printer aperture, the problem of printed-in Newton's rings may arise. By contact printing using a liquid having an index of refraction close to that of gelatin between the negative and print emulsions, the exposing light passes from the negative emulsion through a continuous optical medium to the print emulsion. Thus Newton's rings are avoided.

The liquid should:

1. Produce no adverse effects on the print raw stock such as
   (a) curl, softening, shrinking;
   (b) sensitometric change — fog, densitization, sensitization; and
   (c) change in processed image characteristics.
2. Produce no adverse effects on the negative film such as
   (a) curl, softening, shrinking; and
   (b) change in image.
3. Produce no adverse effects on the positive process
   (a) Preferably no residue should be left on positive film; any residue should have no effect on processing.
4. Have a refractive index of approximately 1.5. (Index of refraction of gelatin is approximately 1.52; index of refraction of support is approximately 1.48.)
5. Be nonflammable.
6. Be nontoxic.
7. Be easily removed from negative and print films.
8. Preferably be colorless and non-turbid.
9. Have suitable wetting and viscosity characteristics.

* General Electric Co., Silicone Products Dept., Waterford, N.Y.

Preliminary Experiments

The first liquid printing tests were made with the primary idea that the use of liquids in contact printing would improve the definition of pictures printed from Eastman Color Negative Film, Type 5248, onto Eastman Color Print Film, Type 5382.

Preliminary experiments were made printing short lengths of 5248 onto 5382 in a printing frame using a specular light source and a highly diffused light source. The table below lists the liquids tested and the results. Check prints were made dry.

Experiments were then made on a Bell & Howell, Model D, 35mm, continuous motion-picture printer operating at 60 ft/min. Chlorobenzene, with an index of refraction of approximately 1.52, was chosen as the liquid since its index is close to that of gelatin (approximately 1.52) and acetate support (approximately 1.48). This liquid evaporates rapidly so offers no problems in removal. However, it is highly toxic.

The liquid was applied to the emulsion side of the Type 5248 negative by a wick or bead applicator at a point just ahead of the printing aperture (Fig. 2). However, the wick fed the liquid to the negative unevenly leaving large unwetted areas which showed on projection of the print. It appeared, then, that wringer rollers were needed ahead of the printing aperture to roll the liquid evenly between the films. Because of the toxic hazard, further experiments with chlorobenzene were abandoned.

Repeat tests were made using Stoddard Solvent and Freon-113 liquid. The same problems were encountered in these tests as in the earlier tests with chlorobenzene. Moreover, Stoddard Solvent did not evaporate readily from the film and had to be removed by wiping. Freon-113 liquid evaporated so rapidly that complete coverage of the picture area could not be achieved. However, where good liquid coverage had been accomplished, print sharpness was noticeably improved.

The liquid applicator was modified so that the liquid was applied to the emulsion surfaces of both the print and negative films, and the inside of the printer housing was pressurized. Repeat tests were made with Stoddard Solvent and Freon-113 liquid and a check print was made dry. Again, neither liquid could be applied evenly between the negative and print films. Moreover, the check print made dry was almost as sharp as those areas on the wet prints where liquid contact had been achieved.

However, an interesting effect was noted in these experiments which dictated a complete change in the course of the project. Where overapplication of the liquid had occurred and some of the liquid had run over onto the *support* side of the negative film, severe scratches on the negative support did not print onto the positive film. Since it would be extremely difficult and untidy to apply the liquid to both the emulsion and support sides of the negative film on this type of printer, it was decided that an entirely new approach was required.

Liquid	*Approx. Index of Refraction*	*Results*
1. Diiodomethane	1.70	Difficult to remove.
2. α-Bromonaphthalene	1.66	Left waxy surface on film.
3. Iodobenzene	1.62	Difficult to remove, toxic.
4. *m*-Nitrotoluene	1.55	Dissolves negative support, flammable.
5. Nitrobenzene	1.55	Dissolves support plasticizer, flammable.
6. Chlorobenzene	1.52	Dissolves support plasticizer, toxic.
7. Tetrachloroethylene	1.50	Good printing results.
8. Tetrachloroethane	1.48	Dissolves negative support, explosive in presence of water.
9. Trichloroethylene	1.48	Excellent printing results, dissolves support plasticizer, somewhat toxic.
10. Refractasil	1.46	Good printing results, difficult to remove.
11. Chloroform	1.45	Toxic.
12. Cyclohexanone	1.45	Dissolves negative support, flammable.
13. Stoddard Solvent	1.43	Excellent printing results, difficult to remove.
14. Dioxane	1.42	Dissolves support and antihalation backing, flammable.
15. Tertiary butyl alcohol	1.39	Dissolves plasticizer and antihalation backing, difficult to remove, flammable.
16. *n*-Heptane	1.39	Flammable.
17. Freon-113 liquid	1.36	Good printing results, slightly toxic.
18. Methanol	1.33	Dissolves support and antihalation backing, flammable.

Design of a Contact, Step Liquid-Immersion Printer

A contact step printer was designed incorporating a Mitchell camera movement so that both the negative and print films would be totally submerged in a liquid at the printing aperture. For these experiments a Mitchell camera movement was chosen in preference to a Bell & Howell shuttle movement since the Mitchell movement could "slide" the films through the liquid while the Bell & Howell shuttle would move the films up and down in the liquid causing an impossible splashing problem and great turbulence. Such a step contact printer would have several advantages over the Bell & Howell Model D, where the liquid would have to be applied to the films by some sort of application device. It would be much simpler to maintain a continuous liquid layer between the emulsion surfaces of the negative and the print films; greater latitude would be afforded in the choice of liquids having indices of refraction closer to ideal, since highly volatile liquids could be used; and all surfaces

of both the negative and print films would be coated with the liquid, thus taking advantage of scratch elimination on the negative.

This printer is shown schematically in Fig. 3. The Mitchell camera movement was mounted horizontally on a vertical plywood panel, and an Acme Motion Picture Camera Motor with variable speed selector was coupled to it. A metal tray was located so that the aperture plate and both the negative and positive films would be completely submerged in the liquid. This tray contained a glass window located about ½-in. directly below the aperture of the Mitchell gate.

The registration pins and other moving parts on a Mitchell camera movement are closely fitted and must be well lubricated to prevent damage to the mechanism; therefore, preliminary printing tests were made using Stoddard Solvent and a light lubricating oil! After printing, it was hoped that both the negative and the print films could be washed in a solvent to remove the oil, and then dried (Fig. 3). This proved to be impractical.

At this stage it was decided to limit further experiments to the use of Freon-113 liquid. Although its index of refraction (1.355) is not ideal, it evaporates rapidly, is nonflammable, is of relatively low toxicity, and has no deleterious effects either physical or sensitometric on Type 5248 or Type 5382 film. It was hoped that the practicability of this method of printing could be demonstrated using this liquid rather than have the entire project bog down in time-consuming problems when working with other liquids having impossibly complicating physical or chemical characteristics even if their indices of refraction were more nearly ideal.

Since Freon-113 liquid is a solvent for ordinary lubricants, the registration pins were removed from the Mitchell movement in order to prevent damage due to lack of lubrication. By careful operation of the printer other parts of the mechanism requiring lubrication could be made to operate without damage. In order to remove air trapped between the two films, they were passed between a set of nylon wringer rollers.

A slight improvement in definition was observed in the prints made by liquid immersion over check prints made dry, and the effects of light scratches on the emulsion and heavy scratches on the support of the negative film were nearly eliminated.

Up to this point, all observations had been made by projecting single-frame slides clipped from continuous lengths of motion-picture film. When lengths of motion-picture film were viewed by motion-picture projection numerous problems were uncovered. Air bubbles, trapped in the aperture directly below the negative, appeared as disks wandering through the picture. Minute dirt particles in the ½-in. layer of liquid between the negative and the glass aperture at the bottom of the tray, which had gone unnoticed in still projection, printed through and moved about rapidly in the projected picture.

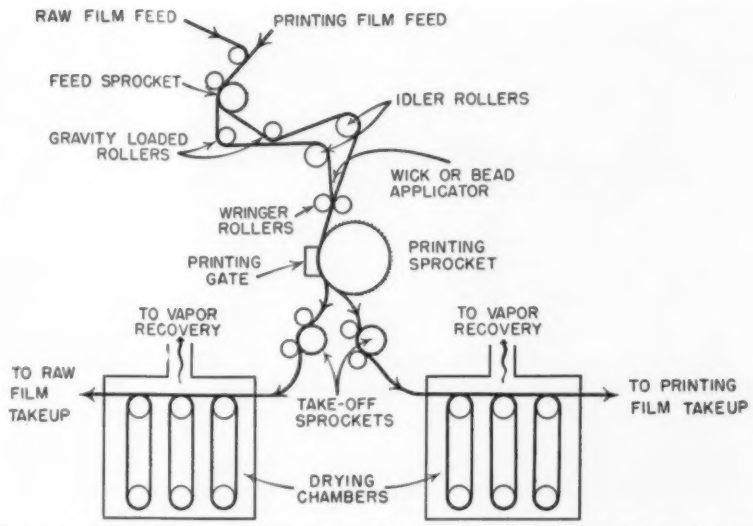

Fig. 2. Schematic diagram of contact, continuous, liquid-gate motion-picture printer, showing method of applying liquid prior to printing.

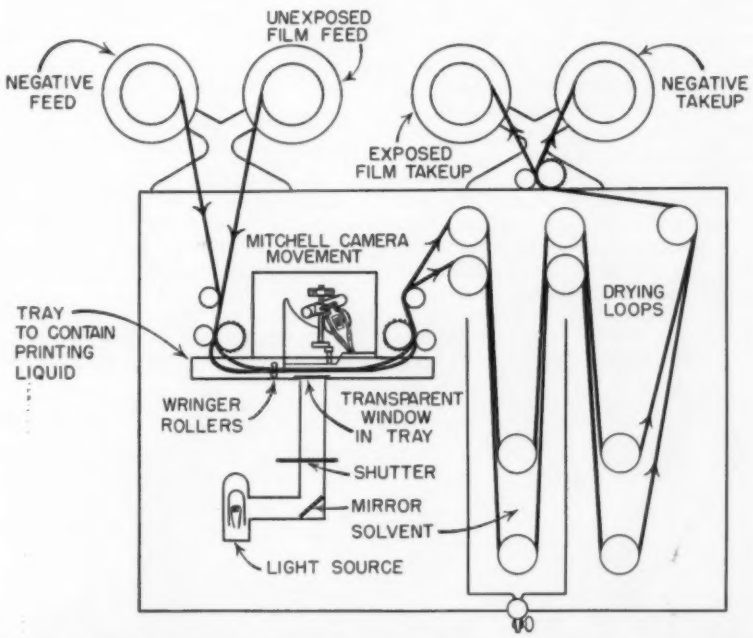

Fig. 3. Schematic diagram of contact, step-registration, liquid-gate motion-picture printer, showing submerged method of printing.

Accordingly, the metal tray was redesigned as shown in Fig. 4. The large reservoir into which the negative and print films entered before printing served to eliminate air bubbles by assuring thorough wetting of the films, and prevented the films from being re-exposed to air by the intermittent action given by the Mitchell camera movement. The aperture of the Mitchell movement was fitted with an optically flat glass window which limited the amount of liquid between the film and the window to an 0.005-in. layer (Fig. 5). These changes eliminated the dirt problem and reduced the effect of air bubbles. However, some air bubbles still formed in the space between the edges of the window and the aperture plate. This condition was eliminated by sealing the glass to the metal aperture with Permatex #2* seal-

* Permatex Co., Inc., Sheepshead Bay, N.Y.

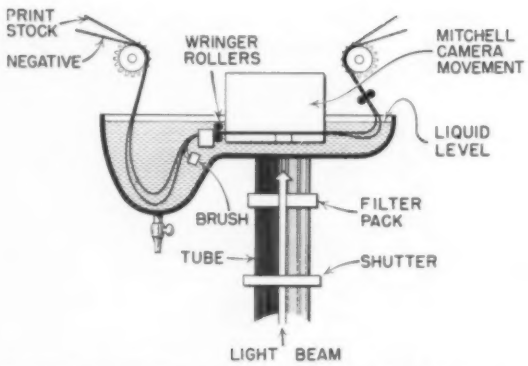

Fig. 4. Diagram of improved tray, showing film path through the liquid.

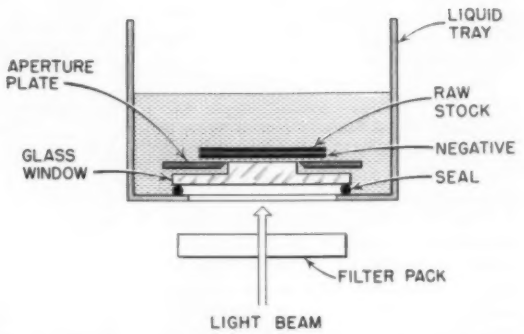

Fig. 5. Cross section of aperture window, showing liquid seal.

ing compound. A camel's hair brush was installed that lightly brushed the negative before it entered the gate serving to remove air bubbles that were carried along by splices. Edge guides were installed between the brush and wringer rollers to assure good contact and alignment of the films. With these modifications, prints free of printed-in dirt and bubbles were achieved. Figure 6 is a photograph of the printer.

It was then possible to evaluate the results of motion-picture contact printing with both the negative and the print films totally submerged in liquid. The printing effect of relatively deep negative support scratches was eliminated, and emulsion scratches which had not disturbed image-bearing layers were eliminated (Fig. 7). While the authors believe there is improvement in sharpness of prints made by this method, it is less than had been originally expected. However, for a dry print to be almost as sharp as a wet print, contact in the printer must be superlative. Perhaps such contact can be achieved only by the use of compressed air which then tends to produce Newton's rings.

The scratched picture in Fig. 7 was made dry on a Bell & Howell, Model D, 35mm printer. The scratch-free picture was made from the same frame of negative on this step contact liquid-immersion printer using this liquid.

Design of Continuous Contact Liquid-Immersion Printer

The physical arrangement of the continuous contact liquid printer is essentially that of a Bell & Howell Printer, Model D, which has been tipped through a right angle so that the direction of the printing beam is upward as shown schematically in Fig. 8. A standard Model D printing sprocket, a pair of wringer rollers, and two idler rollers are the only moving parts submerged in the printing liquid. The sprocket shaft is sealed where it passes through the wall of the liquid vessel by a single O-ring. The sprocket shaft runs in a well-fitted sleeve bearing spaced from the O-ring seal by a narrow flinger disk. The shafts of the feed and take-off sprockets are mounted well above the surface of the liquid on similar bearings. All three sprockets are driven by a single timing belt. A solid steel timing-belt sheave on the printing sprocket shaft acts as a flywheel. The two wringer rollers are mounted in such a position that the two films vee together beneath the surface of the liquid under a sufficient pressure to leave only a thin liquid layer between the films. Excessive wringer pressure is avoided since this has been shown to cause the two films to cling together so tightly that irregular slippage between the negative and raw stock occurs while they pass over the printing sprocket. The wringer rollers are accurately machined cylinders of nylon; one roller has a thin rubber covering to insure evenness of pressure across the films.

Tensioning rollers are provided on both the supply and takeup loops. Greater tension is applied to the supply loops in order to obtain normal running and stripping of the two films on the printing sprocket. Air knives applied to the negative and raw stock film as they leave the printing liquid remove most of the liquid from the films. This liquid runs directly back to the reservoir. The residual liquid is removed by a high-velocity air squeegee which leaves the films essentially dry.

The printing illumination passes through a window in the bottom of the liquid vessel between the flanges of the printing sprocket. On the experimental model metal baffles were used to restrict the light to a printing aperture of the same size as that normally used on a Model D Bell & Howell Printer. On any final design it is contemplated that glass or plastic bars would be used to carry the optical beam. These bars would have blackened outside surfaces to suppress

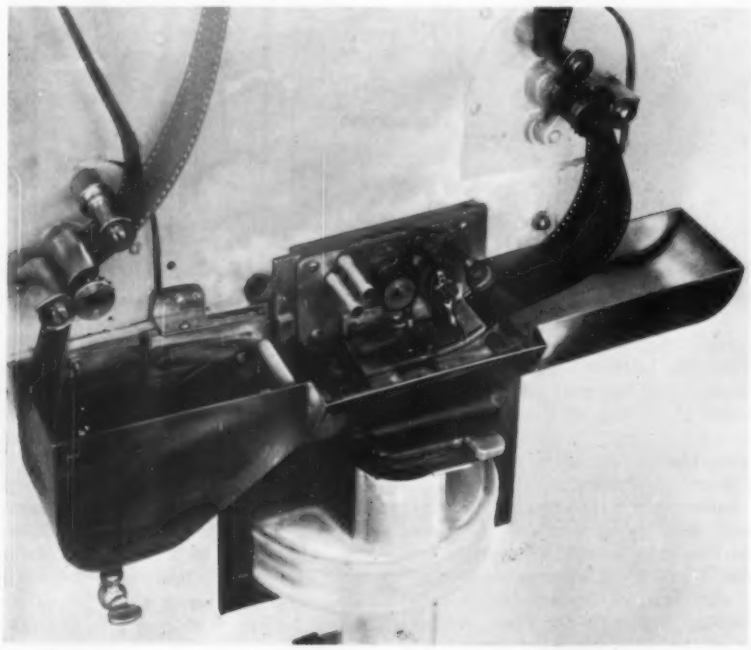

Fig. 6. Photograph of contact, step-registration, liquid-gate motion-picture printer.

transmission or reflection at these surfaces. A rhomboid prism would be used to offset the optical axis at the sprocket shaft so as to obtain radial incidence of the optical axis at the printing aperture.

The printing aperture is illuminated by a condenser relay system designed to provide a beam of light slightly smaller than the light-conducting bars through which it passes. The beam is kept small to avoid reflection at the surfaces of these bars. The relay lens forms an image at the printing aperture of a rectangular diaphragm located at the condenser. The system is adjusted so that this image just fills the aperture. For the experimental model a 500-w lamp was used in conjunction with a condenser system from a Kodaslide Projector, Master Model. This printer is shown in Fig. 9.

Prints on Eastman Color Print Film, Type 5382, made from Eastman Color Negative, Type 5248, have been made on this printer at 200 ft/min using a 500-w incandescent lamp with a 0.45 neutral density in the light beam. Such high printing speeds are possible on this printer since no diffusion need be introduced in the illumination beam in order to minimize the printing effect of cinch marks, abrasions or scratches.

Since the index of refraction of Freon-113 liquid is approximately 1.355, it was expected that results would be further improved if liquids having an index of refraction closer to that of gelatin and acetate support were used. After testing many liquids, a mixture of nine parts of toluene and one part of Freon-113 liquid was found to be the most satisfactory. This mixture is colorless, has low toxicity, is less expensive than Freon-113 liquid alone, and has an index of refraction of 1.50 which is the best compromise possible (increased Freon-113 liquid content reduces the index of refraction of the mixture). The Freon-113 liquid component reduces flash hazards of the mixture. Moreover, the mixture is a good film cleaner!

Remarks

The purpose of these studies was to investigate contact printing motion-picture films using a liquid to promote optical contact between the negative and print films and to minimize printed-through negative scratches. The particular printers described in this paper should not be considered as production models. They were constructed as "bread-board" setups with parts being added as the need for them became evident. Using the basic principles outlined by these studies, laboratories or printer manufacturers should be able to build liquid immersion printers which fit specific laboratory operational requirements.

In this regard, the major problem yet to be solved on a step, registration printer is that of maintaining lubrication of close-

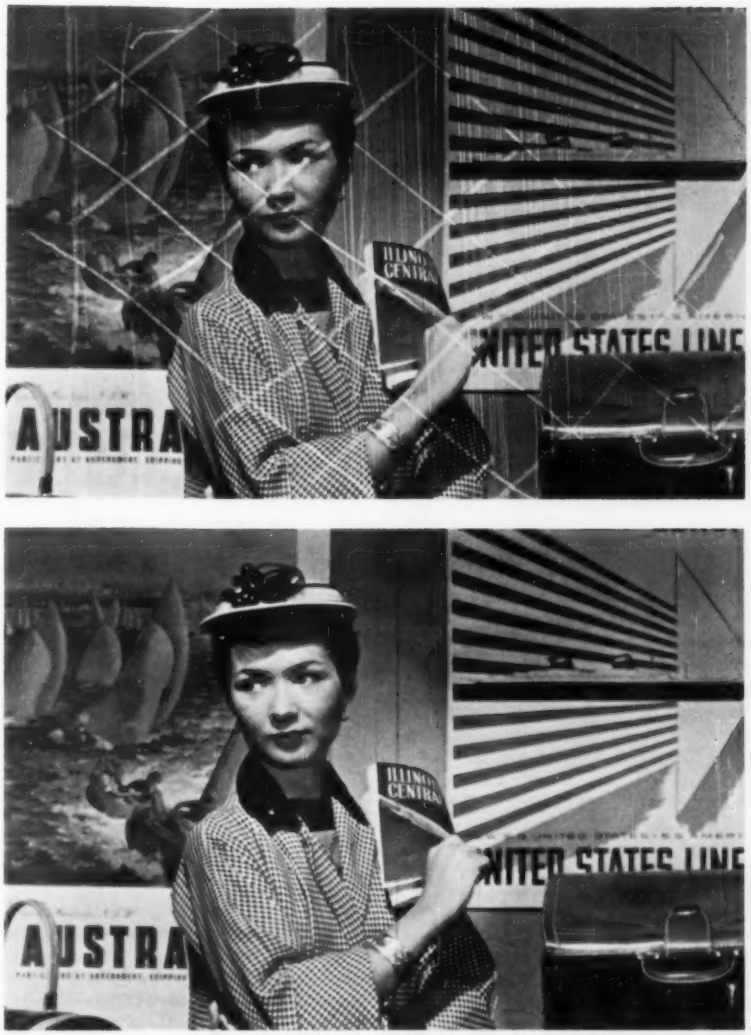

Fig. 7. (Top) Normal print made from scratched negative. (Bottom) Print of same negative made with films immersed in mixture of toluene and Freon-113 liquid.

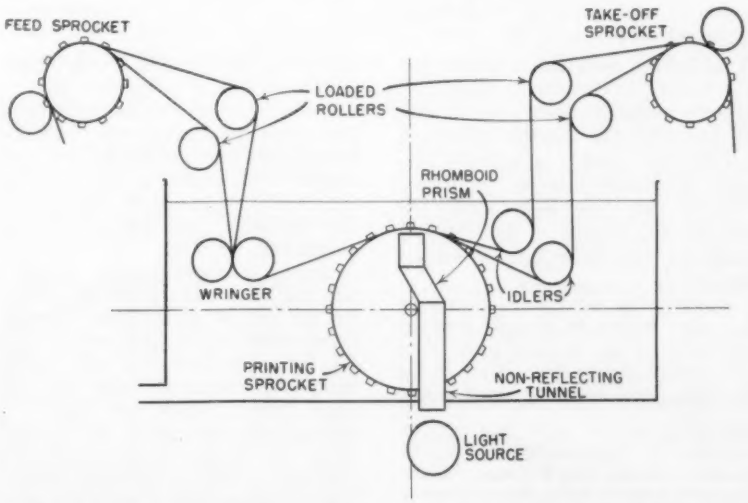

Fig. 8. Schematic diagram of continuous contact liquid-gate motion-picture printer, showing path of film through the liquid.

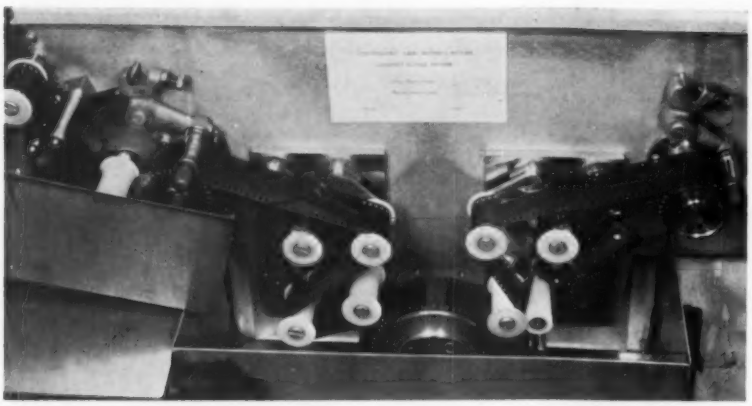

Fig. 9. Photograph of continuous contact liquid-gate motion-picture printer.

fitting parts, such as registration pin bearings, cams, spiral gears, etc., since the only liquids that have proved satisfactory for liquid immersion printing are solvents for lubricating oils. This problem could not be solved using a Mitchell camera movement because the sleeve bearings in which the registration pins move are close to the film plane and are immersed in the liquid. The answer to this problem may involve building film-advancing and registration movements that are located well above the liquid level and shielded from splashes and vapors. The film-engaging pins on oversized supporting arms may then reach the film through gasketted slots in the shield.

While contact, liquid-immersion printers may have somewhat limited use in high-speed release printing because of the added operating problems as compared to conventional dry printers, it is obvious that they may have their major value as salvage printers or in making scratch-free duplicates from original negatives that have been damaged.

An optical printer for liquid-immersion printing has been developed and tested and is reported in Part II of this paper.

Acknowledgments

During this project, two of the authors received other company assignments. Part of the experimental program was then carried on by colleagues whose enthusiasm and ingenious solution of several unsolved problems contributed materially to the success of these studies.

The authors, therefore, wish to express their sincere appreciation to William Weller who conducted many of the printing experiments and recommended liquids to be tested, and to John Turner, Eldyn Graves and Philip Ripson who, in cooperation with the one author remaining on the project, designed and constructed the continuous, liquid-immersion printer from the authors' sketches and preliminary specifications — and made it work.

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1. Otto Sandvik, "Method and apparatus for reproducing sound," U. S. Pat. 2,073,287, Mar. 9, 1937.
2. R. H. Talbot, "New treatment for the prevention of film abrasion and oil mottle," *Jour. SMPE, 36:* 191–198, Feb. 1941.
3. John Wolbarst, "Magic liquid will revolutionize print making," *Modern Photography, 18:* 72–75, 116, 117, 118, Oct. 1954.

Part II: Optical Printing

By JOHN R. TURNER, DUANE E. GRANT and HENRI E. BRETON

A method is described for optical printing motion-picture film by the use of a projection gate that immerses the film in a liquid of matching refractive index. This permits highly specular printing illumination since scratches and surface irregularities on the film have relatively little optical effect under these conditions. Experimental trials of this method have been carried out using Eastman Color films at a speed of 90 ft/min.

THE OPTICAL PRINTING of motion pictures is used, in commercial operations, for a few specialized applications involving relatively small quantities of printed film. Contact printing is generally preferred to optical printing for release prints because of the higher speeds obtainable, and because of the relatively small size and lower cost of contact printers.

The operating speed of optical printers is, in part, limited by the light intensity obtainable at the printing gate. Since most optical picture printers are of the step type, their operating speed is also limited by the dynamic characteristics of the mechanical movements used to advance the object film and the printed film. Some unpublished work concerned with improvements in intermittent film-advance mechanisms has indicated that considerably higher speeds are possible than are usually obtained with existing equipment.

Greatly increased printing illumination can be obtained in optical printing by the use of a completely specular illumination and imaging system. It is well known, however, that such a system tends to accentuate scratches and relief image effects, which will appear as objectionable defects in the printed image. One solution to this problem is to introduce a sufficient amount of diffusion into the system to counteract this effect but this reduces the illumination level. A better solution is to immerse the object film in a liquid of proper refractive index during the printing operation.[1] This paper will discuss the use of liquid immersion for optical step printing.

Presented on May 1, 1957, at the Society's Convention at Washington, D.C., by John G. Stott for the authors, John R. Turner, Duane E. Grant and Henri E. Breton, Color Technology Div., Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

(This paper was received on July 30, 1957.)

Fundamental Aspects of Optical Step Printing Using Liquid Immersion

It is difficult for anyone familiar with conventional motion-picture practice to accept the idea of immersing valuable motion-picture negative film in liquid during optical projection. In judging the practicability of such a technique, it is important to consider the separate physical steps involved:

1. Thorough wetting of the film in such a manner as to exclude bubbles and loose dirt;
2. Optical projection;
3. Mechanical advance of the film; and
4. Removal of liquid from the film after projection.

Each of these steps is fundamentally simple and presents no serious difficulty. Figure 1 shows schematically the wetting and projection steps. The object film being advanced frame by frame enters a flared passage that tapers down to an

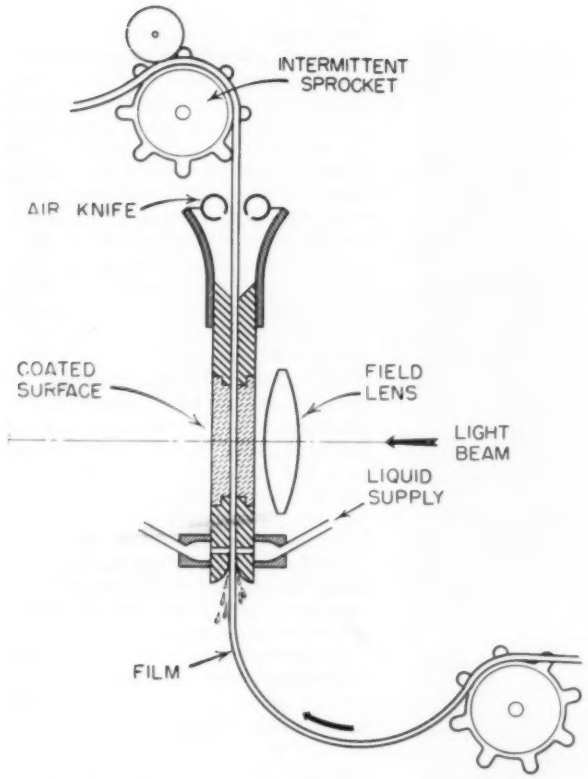

Fig. 1. Schematic diagram of liquid gate for optical printing.

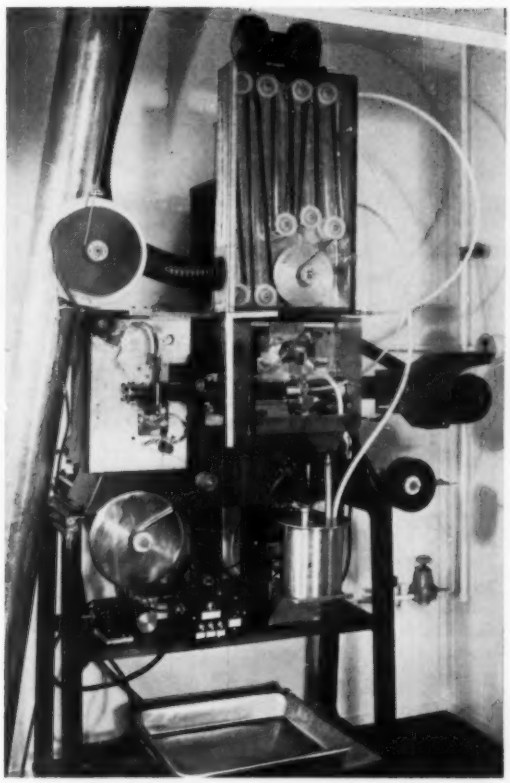

Fig. 2. The liquid-gate, optical, motion-picture printer

opening just large enough to pass a lapped splice. At the entrance to the narrow passage a series of orifices, spaced across the film on both sides, discharges the immersion liquid at a rate considerably greater than that required to follow the advance motion of the film. The excess flow of liquid moving against the direction of motion of the film assures thorough surface wetting, excludes bubbles and loose dirt, and exerts a centering action on the film as it enters the passage. The viscosity of the liquid within the passage is sufficient to maintain the film in the center of the passage during the brief interval of optical projection. The related mechanical and hydraulic factors are similar to those involved in the lubrication of sleeve bearings. In a properly designed liquid gate the emulsion and support surfaces of the film are carried on a cushion of liquid. At suitable operating speeds, the film does not make physical contact with the surfaces of the gate.

The projection aperture is covered by glass windows on each side of the film. This glass is chosen to have a refractive index approximately the same as that of the film and the immersion liquid. The space between the inner surfaces of the windows is sufficiently large that there will be no mechanical contact with the film, but sufficiently small that any slight turbidity of the recirculated immersion liquid will have little perceptible optical effect. A space sufficient for cement splices to pass without touching the windows is necessary. Much more than this is undesirable. The thickness of the windows is great enough so that the few dust particles that might lodge on the outer surfaces would be sufficiently out of focus that their presence would not be apparent. The outer surface of the window toward the objective lens is coated with a non-reflection film to avoid possible halo effects. The physical arrangement of the liquid gate is somewhat similar to that described by O. Sandvik in U.S. Patent No. 2,073,287 issued in 1937 for obtaining improved reproduction from optical soundtracks on motion-picture film.

The mechanical movement, located directly above the projection aperture, may be of a registering type but preferably should not displace the film from the plane of initial wetting and optical projection.

The removal of the liquid from the film after printing is accomplished in three steps. In the first of these, an air knife wipes off the major portion of the liquid, which flows to a drain channel leading back to the recirculation reservoir. In the second stage, an air blast removes most of the remaining liquid from the surface of the film. The third stage is a short drying path that permits the evaporation of a possible residual liquid layer. The drying provisions required depend on the evaporative properties of the immersion liquid. At the high printing speeds possible in this system, some liquids that otherwise might affect the film are usable because the film itself need be wetted for only about one second.

No attempt was made in these experiments to apply the liquid as a thin surface layer on the emulsion and support surfaces of the film. The possibility of liquid printing by this method would be particularly attractive since it would involve a minimum modification to the gate assembly. The application of such a thin surface layer would consist preferably in a thorough wetting of the film to insure adequate penetration of the liquid into the deep scratches, and a subsequent wiping or wringing to insure that the remaining liquid is controlled to a suitable uniform thickness.

One of the problems involved in the use of this method for step printing is obtaining and maintaining the uniform surface layer of liquid while the film is in rapid intermittent motion. Application of a uniform layer of surface liquid might prove to be particularly feasible in continuous printing. Evaporation of the liquid prior to advance of the film into the printing aperture can be suppressed by enveloping the film path up to the printing aperture in an atmosphere saturated with the vapor of the applied liquid.

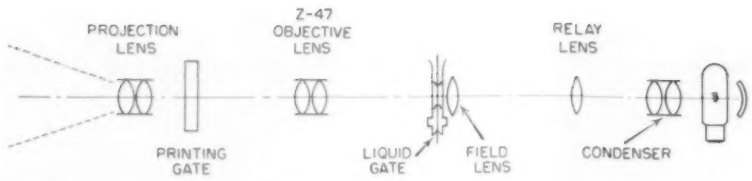

Fig. 3. Optical system of experimental printers.

Experimental Trial of Liquid-Gate Optical Printing

A series of experiments designed to explore the feasibility of liquid-gate optical printing began with a simple gate of the type described. The film was advanced at 90 ft/min with a conventional Geneva movement and sprocket as used in motion-picture projectors. This combination operated surprisingly well. The same subassemblies were later set up on an optical printer.

For these trials an obsolete optical printer was chosen so that modifications would not be objectionable. Figure 2 shows this printer after experimental modifications. Since the original printer was capable of only relatively slow operating speeds, the claw movement at the printing gate was replaced by a Geneva movement and sprocket similar to those used at the projection gate. No virtue is claimed for this arrangement. Projection steadiness, even approaching acceptability in the resulting prints, was obtained only by use of carefully adjusted friction pads in both the projection and printing gates.

An optical system (Fig. 3), consisting of a condenser system from a Kodaslide Projector, Master Model, suitable relay and field lenses and a Kodak Ektar Lens Z-47, was installed on the printer in place of the original components. An additional objective lens was also installed beyond the printing gate for preliminary observation of the optical image when projected on a small screen with no film in the printing gate.

The liquid-gate assembly was equipped with a reservoir, a recirculation pump, and a commercial filtration unit designed to remove particles larger than one micron in size. The entire printer was installed in a ventilated enclosure so that a variety of immersion liquids could be tested without serious toxicity or fire hazards from the associated vapors.

Preliminary printing trials were made using Freon-113 liquid as the immersion medium. The index of refraction of Freon-113 liquid does not match the index of triacetate support closely enough to obliterate severe scratches. In subsequent trials, a mixture of toluene and Freon-113 liquid was found to be reasonably satisfactory. If the mixture contains 10 to 15% of Freon-113 liquid, serious flash hazards are avoided and the refractive index is satisfactory; a higher content reduces the refractive index undesirably.

The flammability characteristics of the above mixture were checked by brief tests to insure that no serious hazard was present during these printing experiments. The actual use of such solvent mixtures in commercial printing operations would be subject to safety regulations and insurance underwriter specifications which would, to some extent, depend upon the locality and the associated operating conditions.

The toxicity of these solvents is considered to be relatively low. It is our understanding that a concentration of 200 parts per million of toluene vapor is the maximum permissible, and that the permissible limit for Freon-113 liquid is considerably greater than this. However, since individuals vary in their reactions to chemicals it is desirable that the concentrations in the air be maintained below these limits.

The hooded printer enclosure used in these experiments was considered to be a more than adequate protection against the relatively moderate toxicity of these solvents. Local exhaust at a properly designed liquid gate should provide an adequate safeguard from vapors. The possibility exists that over a period of reuse of this mixture the content of Freon-113 liquid, through selective evaporation, might be lowered enough to give inadequate protection against the flammability of the toluene component. Also, in the use of these solvents, provision should be made for a separate exhaust at the floor level to pick up any heavy vapors that might tend to stratify below the room air.

It was found that a 300-w projection lamp was adequate for printing an average density negative on Eastman Color Negative Film, Type 5248, onto Eastman Color Print Film, Type 5382, operating with 95 v on the lamp and at a printer speed of 90 ft/min. Under these conditions, the objective lens was stopped down to give an effective aperture of *f*/11.0 at 1:1 magnification. A 0.30 neutral density filter was interposed in order to reduce the illumination sufficiently to obtain normal print density.

Results of Printing Trials

Test negatives, including a resolving-power chart and a variety of pictorial material, were printed under the previously described conditions. Some of these negatives were scratched sufficiently to appear objectionable in a contact print. The same negatives were printed on a Bell & Howell Printer, Model D, and on an Acme Optical Printer set up for standard printing conditions to provide a moderate amount of diffusion. The prints made on the various printers were then critically compared.

It was apparent that the sharpness obtained in the experimental prints made by the use of the liquid gate was at least as good as that on the comparison prints made on the other printers. Drift out of focus was not evident in the liquid-gate printing.

The almost complete elimination of the appearance of heavy support scratches, and light emulsion scratches, in the prints made with the liquid gate was very striking when compared to prints made from the same negative on the other two printers.

There is no evidence in the experimental prints of bubbles in the immersion liquid at the projection aperture when the liquid supply system was adjusted for normal operation.

Effects of surface granularity and relief image, which are sometimes seen in optical prints made with insufficient diffuseness of illumination, were not evident in prints made with the liquid gate.

No undesired optical effects were observed in the prints made with the liquid gate except for flare due to inadequate baffling of the optical system used on the experimental printer. It was anticipated that the high degree of specularity in the printing illumination on the experimental printer might possibly result in unusual refractive effects in the emulsion layer.

No noticeable difference in graininess was apparent in the optical prints made in the conventional manner as compared to those made by the use of the liquid gate.

On some color negative films a Callier Q factor greater than 1.00, and sometimes as great as 1.20, may be associated with surface conditions resulting from some conditions and types of bleaching. Prints made from such negative film may show serious contrast mismatch between layers when printed with specular illumination. Negative printing densities as seen in the liquid gate under highly specular illumination have a Q factor of essentially 1.00 for surface conditions normally associated with the bleaches used for Eastman Color Negative Film, Type 5248.

Photographic reproductions of two prints made from a negative frame that had scratches on the support surface are shown in Fig. 4. Print (Fig. 4A) was exposed in the liquid-immersion optical printer. Print (Fig. 4B) is a corresponding print exposed on an Acme Optical Printer. This print does not necessarily

represent the degree of scratch elimination obtainable on this printer but simply indicates the relative appearance of scratches under one set of conditions.

Conclusions

The design of the liquid gate used in these experiments is considered to be preliminary. Several improvements have been worked out based on experience with the present model. These improvements are to be incorporated in future design for an optical printing head. An indication of the possibilities of liquid-gate optical printing is shown by the results of these experimental trials. Successful commercial use would depend on the availability of suitable equipment and the selection of proper conditions of operation.

With these qualifications, the following applications of liquid-immersion optical projection appear to be of potential practical value:

1. The optical reduction printing of release prints from wider negatives;
2. The printing of intermediates of good quality from scratched negatives;
3. High quality release printing for special presentations; and
4. Possible use in theater projection to obtain maximum sharpness and minimum drift of film in the gate. Projection of wide film, or of 16mm film illuminated at high intensity to fill a large screen, might benefit particularly from liquid immersion.

No statement herein should be considered as an inducement or recommendation for the use of any process, substance or apparatus which infringes a patent.

Acknowledgment

The authors wish to acknowledge the assistance given by William Weller and Philip Ripson of the Color Technology Division as well as by others in this and other divisions of the Eastman Kodak Co.

Reference

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Discussion

R. Paul Ireland (EDL Co., Gary, Ind.): You mentioned that you hope to apply this to an Acme printer. This would involve the motion of the film plane, would it not?

Mr. Stott: No, you could replace the projection head that's on an Acme printer with one of these liquid gates having some sort of a claw pulldown. I don't believe we'd use a Geneva movement because of the unsteadiness problem.

Dr. C. R. Daily (Paramount Studios): Is any experimental work under way applying this liquid gate to high-intensity theater projection?

Mr. Stott: No, not at the present time, but this is being considered. There is some work planned but it has not yet been started.

Dr. Daily: It may be interesting to note that we have experimented at Paramount Studios with the wick application of Freon 113 to film in high-intensity projectors. If the liquid completely covered the projected portion of the film while it was in the gate, the buckle of the film was reduced about 40%, and the film came out "cold." The visibility of scratches was also less. However, the film image as seen on the screen had a slightly watery appearance which was undesirable.

V. E. Patterson (Telex Films, Hyattsville, Md.): On the one slide where you had the air squeegee above the gate, what was done to prevent agitation down in the gate with the air blowing down?

Mr. Stott: The air blast didn't reach into the gate when printing actually took place.

Sidney P. Solow (Consolidated Film Industries): I think that no one can help being impressed by the dramatic courage and spectacular results of these experiments, and the authors are to be complimented for their enterprise. However, I would like to suggest that the validity of this demonstration could be increased if the same scratched negatives — or sections of them — were submitted as controls to the existing and apparently effective rejuvenation or de-scratching treatments which are available in New York City. The value of the liquid technique as a salvage measure could then be compared adequately with methods already at hand.

Of course, there is one situation in the film laboratory where the immersion technique would obviate many of the present difficulties. I refer to reduction printing from 35mm color negatives to 16mm color positives. If the reliability of operation and efficiency of solvent recovery can be established in this field of laboratory production, then color reduction printing from original color negatives to obtain 16mm color release prints could become a prudent routine procedure.

Figure 4A

Figure 4B

Fig. 4. Comparison of prints made by liquid-gate optical printer (A) and by conventional printer (B).

Data-Recording Xenon Flashlamp

By EDWARD A. COLSON
and HAROLD E. EDGERTON

This paper describes an electronic flashtube which is designed primarily for data-recording applications in modern military aircraft where it is desired to obtain photographic records of moving dials, etc. The FX-4 is explosionproof, waterproof and is able to withstand rigid shock and vibration requirements of modern aircraft. The lamp is completely encapsulated in an epoxy resin, permitting the tube to be operated at altitudes of 70,000 ft or submerged in water. It is resistant to extreme temperature variations, shock and vibrations. Typical examples of its applications are described.

TODAY the use of high-speed electronic flash techniques for motion-stopping photography is familiar to most people in the technical photography profession. Familiar examples are pictures of a hummingbird in flight apparently stopped in mid-air, sequence pictures of a hammer crashing through a light bulb, and bullets "stopped" in flight, etc.

A new flashtube has been specifically designed for data recording under the environmental conditions that one encounters in military aircraft. There appear to be numerous occasions when one would like to record on film the instantaneous readings of such things as dials, position indicators, azimuth, range, speed, and other types of indicators, etc. In some instances these indicators may be moving quite rapidly.

One of the tasks which Edgerton, Germeshausen & Grier, Inc., encountered on an Air Force contract was the measurement of a time interval to the nearest hundredth part of a second. Specifically, the task was to measure precisely the time interval between two transient electrical signals without having prior knowledge of when these two transients would occur. In order to obtain a recording from which this time interval could be measured, a pair of synchronized clock dials was used. One clock dial was illuminated at the instant the first transient occurred; the second clock dial was illuminated at the instant that the second transient occurred. The difference in readings, as recorded on film, was the time interval measured.

The solution appeared obvious until a search was initiated to locate a suitable flashtube compatible with the environment of military aircraft. Existing commercial tubes were either too large, too fragile, or otherwise were not suited for use in the environment of military aircraft.

Accordingly, a flashtube was developed specifically to provide data-recording illumination for operation in this kind of environment. This flashtube is EG&G's Type FX-4 and is shown in Fig. 1. Along with the photograph of the flashtube is a sketch which shows more clearly its construction details. It is a glass tube embedded in an epoxy-type plastic. The glass tube itself has two electrodes, one at each end, which form the cathode and anode, respectively. A trigger electrode wire is wrapped around the outside of the glass tube. Wire leads with vinyl insulation are attached to these three electrodes. This glass-tube assembly is then embedded in a transparent epoxy-type resin to provide mechanical ruggedness and electrical insulation. This then provides a light source which can be placed in any space large enough to hold the flashtube and which may be subjected to extreme conditions of shock and vibration.

A problem always encountered with the triggered xenon flashtubes, such as this one, has been the high voltage required for triggering. It requires the order of 7000 v for about 1 μsec to start one of these flashtubes. Although this is no particular problem under ordinary laboratory conditions, it becomes a serious problem if the tube must be operated either in an explosive atmosphere, at extreme altitudes, or under other unusual conditions. Thus, the complete encapsulation of the tube and its external electrodes makes operation under these extreme conditions feasible. The epoxy resin also provides insulation of the glass structure against thermal shock. For instance, it is possible to move this tube from a temperature environment of −55 C to one at +95 C repeatedly without causing any mechanical damage. The flashtube is designed to be operable over this same extreme temperature range.

The tube has been operated successfully when immersed in water and other liquids. In another instance, two of the encapsulated FX-4 flashtubes were used with a special camera to take photographs inside a gas well. It has even been suggested by a physician that it may be

Presented on May 3, 1957, at the Society's Convention at Washington, D.C., by Edward A. Colson (who read the paper) and Harold E. Edgerton, Edgerton, Germeshausen & Grier, Inc., 160 Brookline Ave., Boston 15, Mass.
(This paper was received on May 3, 1957.)

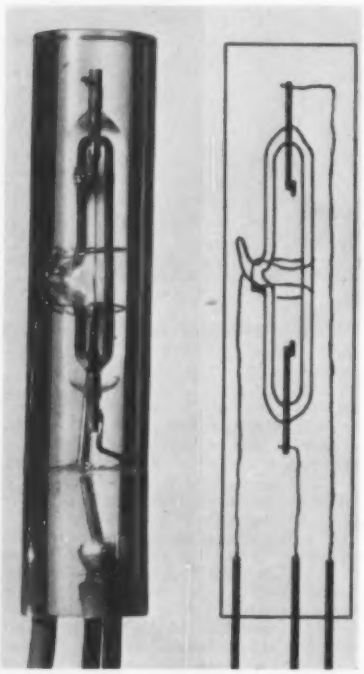

Fig. 1. Type FX-4 flashtube and sketch of its construction details.

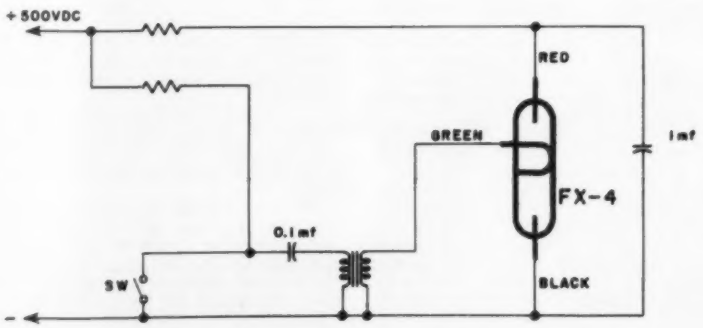

Fig. 2. Simplified schematic of typical FX-4 flashtube circuit.

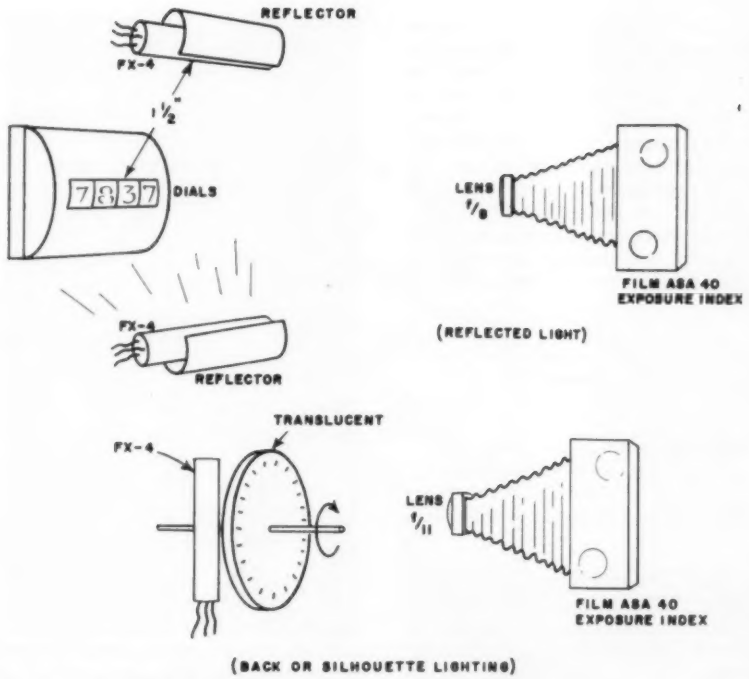

Fig. 3. Typical FX-4 flashtube applications.

useful in photographing the interior of a human stomach for diagnostic purposes.

A large amount of illumination is not usually necessary for data recording, hence the energy required is modest. It is provided by charging a 1-μf capacitor to 500 v, a nominal $\frac{1}{4}$ wsec.

A simplified schematic of a typical circuit application is shown in Fig. 2. The essential elements are the flashtube, the energy storage capacitor, the trigger transformer, and the switch to cause the trigger pulse to occur. This switch may be a pair of electrical contacts, a thyratron, or a gaseous trigger tube such as the OA5.

Some suggested methods of using this flashtube are illustrated in Fig. 3. In one instance, the object is to be photographed by reflected illumination. In this case, it is usually far more satisfactory to use two flashtubes placed as shown in the sketch. Sometimes it is possible to backlight the subject to be photographed as shown in the second sketch. In this case, translucent dials are used and space for the flashtube must be provided behind the object to be photographed. In these sketches are shown typical lens and film combinations for satisfactory photographs. Usually, however, each application is unique, such that the optimum results may be obtainable at other values. Successful results are obtained with Polaroid film.

The time duration of the light-flash has been measured and is shown in Fig. 4 plotted as a function of voltage across the capacitor for three values of capacitance. The duration is defined as the time for the light to diminish to one-third of its peak value.

The light output of the FX-4 flashtube is shown in Fig. 5 wherein horizontal candlepower is plotted as a function of capacitor voltage for three values of capacitance. Note that there are two limiting conditions, a minimum voltage below which the tube will not flash when supplied with a triggering pulse, and a maximum voltage over which the tube is self-starting.

Certain other limitations common to all electronic flashtubes will occur to the reader, such as maximum energy per flash, and maximum flashing rates at a given energy per flash. Usually each application is unique; hence, it is not prudent to make general statements regarding these limitations. It is suggested that the manufacturer be contacted for specific information.

The life of the tube, or more specifically, the number of flashes which the tube will produce before failure, is

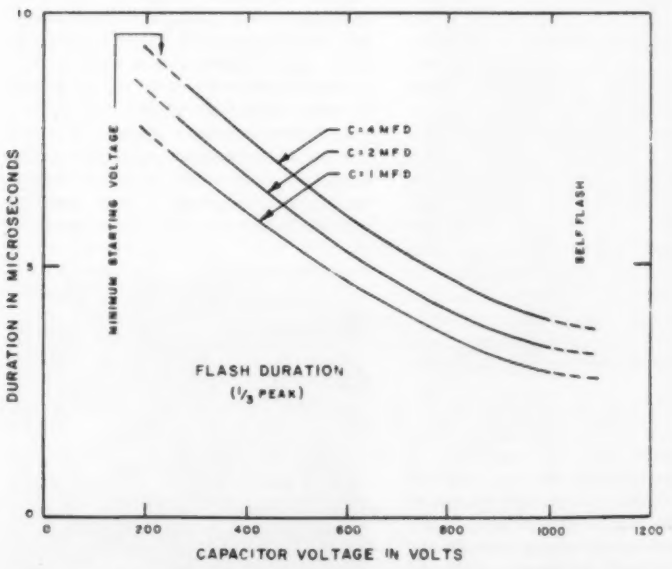

Fig. 4. Light-flash time-duration curves measured by the FX-4 flashtube.

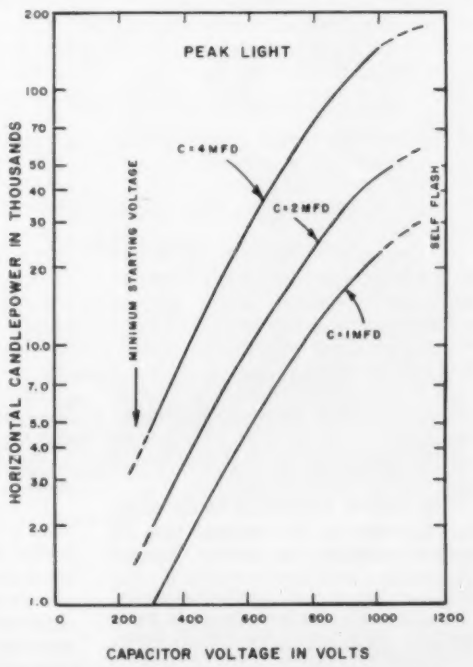

Fig. 5. Curves of light output of the FX-4 flashtube.

dependent upon the operating parameters of energy per flash and flash-repetition rate. An FX-4 flashtube, when operated at a rate of 1 flash/sec with an energy input of $\frac{1}{4}$ wsec will normally be good for a minimum of 4000 light flashes. If greater life is necessary, less energy per flash at a lower repetition rate is recommended. If it is desired to obtain only a few data recordings and the setup cost of obtaining these few is high, it may be well worth overloading the tube for perhaps 10 or 100 flashes and sacrificing the tube. This would be feasible when it is necessary to send five men and an airplane on a mission to obtain only a half-dozen data records. Another example has been cited previously wherein the interior of a gas well was photographed at a relatively high setup cost. Here, short flashtube life was an acceptable compromise in order to obtain a few valuable photographs. Certainly, the person whose stomach will be photographed from the inside will probably not be interested in a flashtube capable of flashing several thousand times.

The FX-4 flashtube which has been described is small in size and ruggedly built to withstand extreme environments in photographic data-recording of indicating-type dials, meters, etc. Some applications have been described, and certainly many other applications can be imagined.

Portable Power Supply for High-Speed Cameras

By DONALD H. PETERSON and NIEL G. CURRIE

A new portable power supply has been designed for operation of high-speed cameras in temporary locations. Objective was to have a mobile operational unit which could be taken to test site and placed in service quickly, with all necessary electrical power obtained from the plant's 3-phase power system. An enclosed trailer contains a permanent installation of transformers, electrical distribution systems and circuit controls, and provides storage space for cameras and accessories. The cameraman's remote panel which controls operation of lights, cameras and test event can also function as control center for complete test program and all instrumentation.

Much of the data on ground test operations in aviation development are now recorded by high-speed motion-picture photography. Increasing reliance on the camera as a recording instrument has brought about a need for development of operational support equipment, incorporating cameras as part of an instrumentation system. Two activities that rely heavily on the high-speed camera are engineering test operations and manufacturing method studies. The requirements for recording data for both these fields of endeavor are widely diversified.

One necessity common to all uses is an adequate source of electrical power and circuit controls which permits accurate time synchronization of cameras, test event, and other instrumentation. The unit described in this paper is designed to combine high-speed cameras of several types into an instrumentation system which can be put into service easily and quickly anywhere in the company's field of operation.

The present integration of the high-speed camera as an essential item in testing programs has greatly changed the way of using the camera since its introduction into the aviation industry about 15 years ago. At that time the information desired was of a qualitative nature and could usually be obtained with a single camera. Coordination of test event and camera was usually satisfactory when done by manual control since the picture-taking rates were moderate. Electrical power needed to operate the camera motor and the lights ordinarily did not exceed the normal supply available in the work area. This rather simple situation was soon changed by more complex aircraft design requirements and by a recognition of the ability of the camera to supply otherwise unavailable information. As the frequency and scope of applications expanded emphasis gradually shifted from the question of "what happens?" to "what are the time and distance measurements of the motion?" Thus the high-speed camera came into recognized use as an instrument for dynamic measurement.

In today's more complex test operations and concern for quantitative data, it has become common procedure to use a group of several cameras, each one of which fulfills a separate purpose. These individual uses can be grouped into three categories: visual presentation of action; overall informational views; and detailed views of special local areas. Visual presentation is done at normal camera speed; overall views may be at medium or high speeds as the subject action requires, and local views of special areas are usually taken at high camera speeds. Because of the complexity and cost of the test operation, this is the most economical method of obtaining maximum data yield.

Several factors concerning camera operating procedure must be considered in order to use each camera to best advantage, and to achieve the desired coordination with the rest of the test program. Higher camera speeds reduce the picture-taking time capacity, for a given film capacity. Timing of the subject action to occur at the desired point during the camera's run has become critical. Electrical power needs for multiple-camera operation and for high-level lighting have increased to a point where sufficient capacity is usually available only from 3-phase power circuits. Repeated efforts resulted in the obtaining of data which in reliability compared with those obtained from permanent test locations such as the wind-tunnels. Formerly there was obtained at best a noticeable compromise. The need to provide better service for this sector of

Fig. 1. Portable power supply trailer.

Presented on October 10, 1956, at the Society's Convention at Los Angeles by Donald H. Peterson (who read the paper) and Niel G. Currie, North American Aviation, International Airport, Los Angeles 45.
(This paper was received on July 23, 1957.)

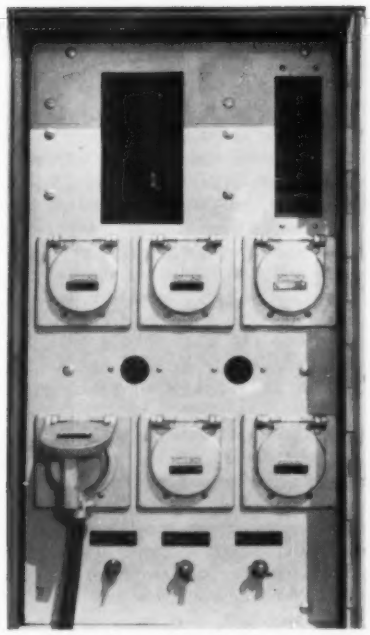

Fig. 2. Breakers, light circuit receptacles and auxiliary power terminals.

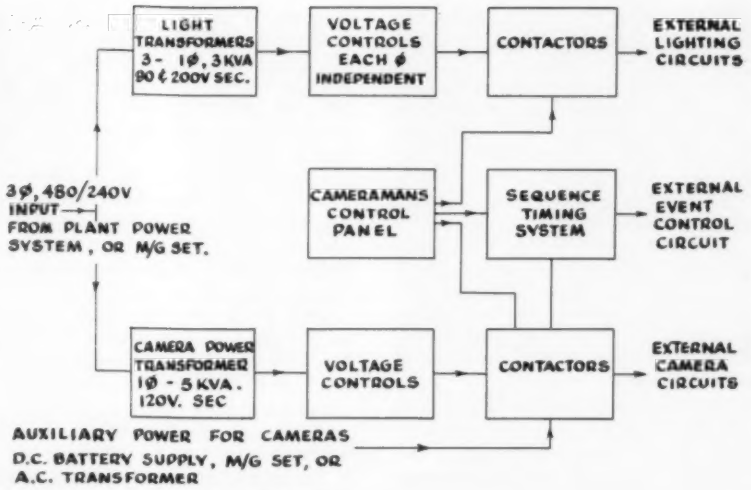
LIGHT TRANSFORMERS 3 - 1ø, 3 KVA 90 & 200V SEC.
VOLTAGE CONTROLS EACH ø INDEPENDENT
CONTACTORS
EXTERNAL LIGHTING CIRCUITS
3ø, 480/240V INPUT FROM PLANT POWER SYSTEM, OR M/G SET.
CAMERAMANS CONTROL PANEL
SEQUENCE TIMING SYSTEM
EXTERNAL EVENT CONTROL CIRCUIT
CAMERA POWER TRANSFORMER 1ø - 5 KVA. 120V. SEC
VOLTAGE CONTROLS
CONTACTORS
EXTERNAL CAMERA CIRCUITS
AUXILIARY POWER FOR CAMERAS
D.C. BATTERY SUPPLY, M/G SET, OR A.C. TRANSFORMER

Fig. 3. Power supply and control system.

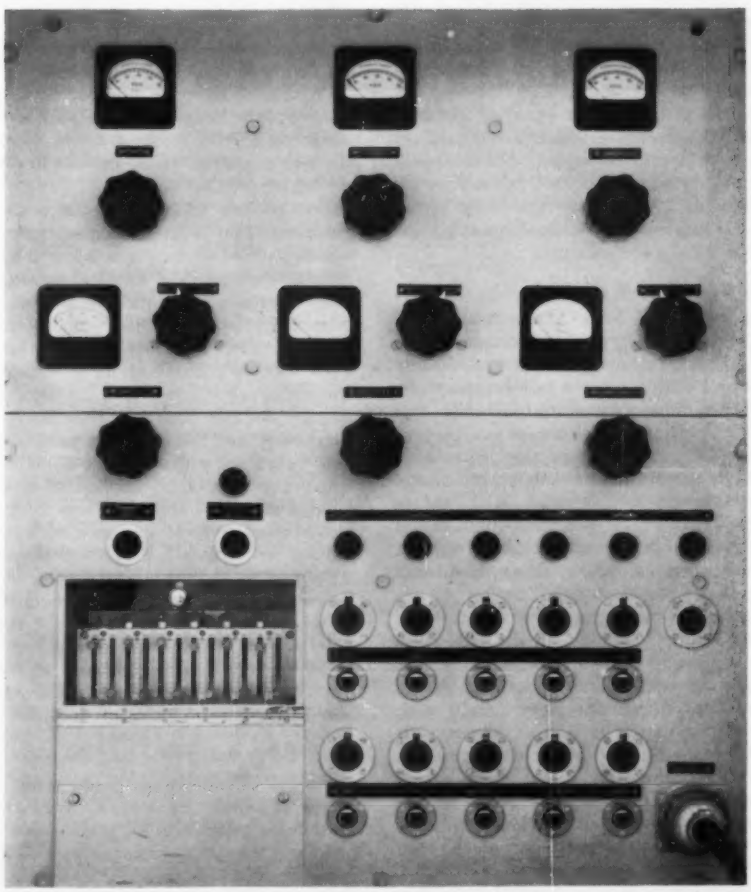

Fig. 4. Operating panel: upper controls select camera voltages; center, lamp voltages; timer and camera circuit receptacles at bottom.

test activities, conducted in temporary areas and field locations, warranted the design and manufacture of a portable power supply with an integral control system.

Electrical power requirements and control facilities were established from current and future work schedules. Specifications and circuit designs were completed in early 1956 and an order for final design and manufacture of the unit was placed with the firm of Shapiro and Edwards, South Pasadena, Calif. Delivery was made in midyear, and the unit is now in use.

The completed unit shown in Fig. 1, has a welded steel body which is spring-mounted on a four-wheel chassis. Since mobility was one of the prime requirements it was decided that a trailer of weather-tight construction would provide the most practical combination of transportation vehicle and apparatus storage needs. Access to all outer surfaces was accomplished by mounting the transformers and contactor panels in the central body space. Compartments along both sides provide storage space for lamps, cable, and one Mitchell tripod. Cameras are stored in the compartment at the front end. Doors at the rear end open to expose a recessed panel having the operating controls and camera circuit receptacles. The power input receptacle is mounted at a 45° angle under the body overhang, and can be seen about midway between the front and rear wheels. The single panel door just above the right front wheel exposes the circuit breaker and lighting output panel shown in Fig. 2. Normal storage for the usual complement of equipment is provided by having all compartment doors weather-tight and fitted with tumbler locks. Parking brakes were installed on the rear wheels to assure a stable position on occasions when the flat top of the unit would have to serve as a camera platform.

The purpose of this unit is to include all items used in a high-speed motion-picture operation within an instrumentation system stored within the vehicle

and operated through the unit's control center. Achievement of this objective required the evaluation and selection of proper amounts of individual components to form an adequate but flexible system able to handle most work situations without support from other sources. All electrical power for normal demands is supplied on the unit's output panels, and is obtained from a single connection to the plant power system. Expanded capacity for unusual demands is obtained from other suitable sources and fed into the unit through two auxiliary inputs. However, all auxiliary power is still switched by the unit's control system, and distributed on the output panel. This permits doubling the total camera operating capacity, yet does not incur any loss of circuit control facility. The auxiliary inputs are also a convenient way to provide for operation of cameras requiring power other than 60-cycle a–c.

Electrical apparatus installed in the unit actually comprises several separate electrical systems (Fig. 3). Included are the lighting system, camera power system, sequence timing, sequence test, and event control. Power input for the unit is 3-phase, 480-v, which is standard for power circuits throughout North American Aviation Plants. Operation on 3-phase, 240-v supply is provided for by changing external strap connections on the transformer primaries.

Lighting System

In addition to an adequate supply of power, an important requirement was, and is, flexibility. The most versatile high-intensity sources had proven to be the General Electric PH-750R and PAR-56 lamps which can be maneuvered around structural fixtures or mounted on fixture members which permit lamp placements not possible with larger types. Therefore the circuitry was designed to operate either or both of these two lamps, although almost any lamp up to 5-kva rating may be used.

The 3-phase input power goes through a 30-amp, 3-pole circuit-breaker to three single-phase transformers for the lighting supply. Transformer ratings are 50-amp, output per phase for 10 min, and 3-kva continuous. Each phase feeds two Cannon MI-4-39 receptacles on the output panel (Fig. 2). Branch circuit lines are 50-ft 3-conductor cables terminating in molded-rubber junction boxes with four twist lock receptacles for individual lamp lines.

Operation of the PAR-56 lamp to obtain maximum light output requires a dual or a variable voltage supply. After the filament is preheated, the applied voltage can be raised to as high as 185 v; this produces an efficient high-intensity light output.* Transformer secondaries are tapped at 90 v for the lamp preheat, and at 120 v and 200 v for operating voltages. Each phase has a separate switch for selection of the 120 v or 200 v tap, and a variable auto transformer for variation of either tap voltage. On the 120-v tap the range extends from 95 v to 135 v, and from 160 v to 200 v on the 200-v. Full voltage controls are completely separate from the preheat system, so all lamps are always started on 90 v. With independent full voltage controls on each phase, it is possible to use PH-750R lamps at 120 v on one phase and PAR-56 lamps up to 185 v on another. This feature is useful when the area lighting is done with the somewhat more efficient PAR-56 lamp and physical circumstances favor the smaller PH-750R for local spot lighting.

The output from each phase is divided into two branch circuits for switching convenience, making a total of six light circuits. Contactors energizing these circuits are operated from a group of six toggle switches located on the cameraman's remote panel. During the setting-up operation this gives the cameraman control of the lamps in six groups of four lamps each. After the setup is completed the toggle switches for all circuits in use are left in the "On" position.

For picture taking, the lamps are group-operated from three pushbutton switches on the cameraman's remote panel. Pushing the button marked "Dim" applies 90 v to all lamps. After momentary burning at this voltage, the "Bright" switch is pushed to apply previously selected full voltages to all lamps. Interlocks prevent switching on the full voltage without preheat. This 2-stage lamp start not only provides increased light output by permitting use of higher voltages than can be applied to cold lamp filaments, but has proven useful in two other respects. Burnouts on lamp starting are reduced, and the lighting setup can be appraised better when the lamps are burned at 90 v. This reduction from the brilliant full intensity of the PH-750R to a level within usual eye accommodation makes it easier to see when the desired lighting balance is obtained.

Camera Power System

Design of this system began with a survey of cameras in use and available in the foreseeable future. Our desired operating features were ample power for rapid camera acceleration and versatile timing arrangements for starting cameras independently of each other.

Power supplied by the unit is 60-cycle a-c obtained from a single-phase low-reactance transformer. Output rating is 100 amp for one sec, 80 amp for 10 sec and 5-kva continuous. Power is distributed to five camera circuits, with outlets labeled "a-c" (Fig. 4). A second group of five circuits with outlets labeled "d-c" are energized by the auxiliary power inputs previously described.

The knob labeled "cameras" at the upper left of the panel operates a variable transformer to compensate for power line variations and provides a precise voltage control for camera circuits 3, 4 and 5. This output also feeds the primaries of two other variable transformers for independent voltage control of circuits 1 and 2. By this arrangement we can supply any voltage from 110 v to 130 v on circuits 3, 4 and 5 and any voltage from 0 to 150 v on circuits 1 and 2. Considerable latitude in combinations of fixed and variable voltage types of cameras are at the cameraman's disposal. Precision timed switching of camera circuits 1, 2, 3 and 4 is accomplished through the sequence timing system, while circuit 5 is controlled from a toggle switch on the remote panel. Independent manual control of circuit 5 is to permit some cameras to be started from observed action, for running before and after the timed sequence, and for operation of cameras covering pre-test work.

It became apparent early in the designing that if several cameras were to be operated as an instrumentation system it would be necessary to standardize their electrical hardware. Examination of several connectors furnished on cameras and review of circuit failures experienced indicated appropriate specifications for a standard line. Hardware should be of as few types as possible and of adequate current rating. Fittings should mate easily, yet be securely locked when mated, and should be available through local suppliers.

The limitations of mounting space on camera bodies and a wide range of current demands made it impractical to use one fitting for all cameras; however, specifications were met by selecting two types: for the high current demand of the Eastman and Fastax high-speed cameras, the Cannon P series is specified; and for all others, the Cannon XL series. This standardization has, of course, been plant-wide in its application. There are a total of 20 camera receptacles on the operating panel, four on each of the five circuits. Layout of the panel is such that each vertical column of four receptacles represents a camera circuit from the control standpoint, regardless of source of power for receptacles within each column. The upper horizontal bank is on the unit's a-c system, and has one 30-amp type P and one 15-amp type XL receptacle on each camera circuit. Similarly the lower horizontal bank which is on the auxiliary system has one receptacle of each type per circuit. The auxiliary circuit is divided at the input panel to permit use of two operating voltages. Camera circuits 1 and 2 are separated from circuits 3, 4 and 5.

*J. M. Novajosky, "A rugged and efficient high-speed photographic illumination system, *Jour. SMPTE, 64:* 569–572, Oct. 1955.

Sequence Timing System

This control system provides a reliable precision timing control of camera circuits and coordination with the test event circuit. Sequence, which occurs automatically upon closure of a momentary contact switch, is noninterruptable and is not subject to repeat without reset. The timer is an Eagle Signal Corp. Model HM-623-A-06-07, with six pairs of contacts, and 10-sec cycling time. Circuit 1 of the timer is used to control the timing and reset system. Circuits 2, 3, 4 and 5 operate the contactors which apply power to camera circuits 1 to 4. Circuit 6 closes the relay in the test event circuit. It is possible to obtain 0.1-sec accuracy in adjustment of the "start" setting on each timer circuit, as vernier scales are provided on each of the adjustment knobs. Since stop settings are not critical, they are set on a linear scale with 0.5-sec accuracy.

Sequence Test System

Any sequence established on the timer may be checked with a stop watch by observation of pilot lights on the operating panel. A light representing each timer-controlled circuit is located at the top of the vertical receptacle column for that circuit. A momentary contact pushbutton labeled "Sequence Test" starts the timing cycle which is indicated by the lights. Each light is on for the closed-circuit time setup on the timer for that circuit. This operation does not actuate the event control or camera circuits. A "Reset" pushbutton which is common to both Sequence Test and actual camera operation must be reset before either operation can be repeated. The sequence-locked-out or reset-required condition is indicated by a pilot lamp above the reset button.

Event Control System

This system is for the control of any test event which can be initiated electrically. An accurate time relationship to camera operation is possible by switching this circuit from the sixth channel of the timer.

Whenever Eastman high-speed cameras are used, it is usually preferred to have one of the cameras, rather than the timer, used to control the event. On the camera, time delay for closure of the event circuit is indicated in terms of feet of film. This relationship is of more direct concern to the cameraman than an absolute time delay after a zero starting time. However, this control was warranted in the design of the unit since there are frequent uses of cameras having no event control. This circuit can also be used as a switch to control oscillographs or other recording instrumentation. Connection for this circuit is a pin-insert P series Cannon receptacle located at the right of the top row of camera outlets. A 4-conductor fitting was selected for this purpose to prevent any cross connection between event control and camera power circuits.

Remote Control Panel

Actual operation of lights, start of sequence operation, and manual use of camera circuit 5 is done from the panel of a box measuring 6 × 6 × 2 in. Remote operation is through a 13-conductor 50-ft cable connected to a Cannon RIK-22-32 panel receptacle, shown at the lower right of Fig. 4. Across the top of the remote panel are the six off-on toggle switches for the six light circuits. These provide the convenience of switching the lamps from wherever the cameraman stands during the setting-up operation. Three camera controls are arranged in a row across the panel center. At the left the toggle switch labeled "Camera Five" operates the relay energizing the one camera circuit not on the sequence timer. Center pushbutton marked "Cameras" is a momentary contact switch to start the timed sequence. Any unintentional start which might be made by depressing the "Camera" button is prevented by a safety switch which must be closed before the "Camera" switch is operative. This "Camera Unlock" switch at the right is the third camera control.

The lower row of controls are three pushbutton switches for light operation. At the left is "Off," center is "Dim," and at the right is "Bright." Pressing the dim switch applies 90 v to all the lights. The bright switch then increases the lamp voltage to that preset by the controls on the trailer panel. A sequence-controlled camera run would involve performance of these steps: (1) press Dim switch; (2) press Bright switch; (3) uncover Camera Unlock and throw switch; (4) press Camera switch; (5) after camera run is completed, press light Off switch; (6) switch off and recover Camera Unlock; and (7) press Reset switch on trailer panel. All operations except No. 7 are from the remote control panel.

Fig. 5. Remote panel: the cameraman controls lights and sequences; camera is manually operated from this panel.

General

Protection of power circuits is provided by circuit breakers located directly above light receptacles on the same panel. All light and camera circuits are 3-conductor to carry an equipment ground through the system. Two twistlock receptacles in the center of the light receptacle panel are energized directly from the camera transformer. These provide single-phase power for operation of drill motors, soldering equipment, and similar uses.

Conclusion

In the rather short time this unit has been in use since delivery, it has already demonstrated that the design intentions have been met. Cameras are utilized and programmed to place subject action at the optimum point within the time span of each. It is no longer necessary to compromise overall performance because of different camera acceleration rates and running speeds. Placement of the command control in a reliable timing device has removed many of the hazards involved in manual estimation of time delays. Even the most complex jobs can be duplicated from notes describing camera disposition and timing. Special jobs can be planned with the knowledge that the plan can be executed as well as any of the more usual jobs.

The improved capabilities from the use of this new power supply and control unit are expected to increase the usefulness of the high-speed camera as an engineering tool.

Special thanks are extended to the firm of Shapiro and Edwards for their extra contributions to the design, and for delivery of a first class photo-instrumentation control system.

A Simple Schlieren System for Two Simultaneous Views of a Gas Flow

By GEORGE RUDINGER
and LOWELL M. SOMERS

A conventional schlieren system for the observation of gas flows is modified by the addition of two plane mirrors to provide two simultaneous views of a test section at right angles to each other. Two views of a cylinder hit by a shockwave are presented as an example.

THE CONVENTIONAL schlieren and shadowgraph systems are ideally suited for the study of two-dimensional gas flows, but they are frequently used also for the observation of three-dimensional flows. A better understanding of such flow patterns could often be obtained if the flow field were viewed from two directions. Various schemes have been devised for this purpose. These range from turning of the model for two consecutive photographs,[1] which is feasible only in steady flows, to the simultaneous use of two separated optical systems.[2] A survey of the various optical techniques that have been proposed to give stereoscopic views, or otherwise provide information, about three-dimensional flows has been given by Holder and North.[3]

In most commonly used systems, a parallel beam of light of the size of the schlieren mirrors is transmitted through the test section. Frequently, particularly in shock tube experiments, the available schlieren mirrors are considerably larger than one dimension of the flow field to be investigated. Under these conditions, the conventional schlieren system can be modified to render two simultaneous views at right angles to each other by the addition of only two plane mirrors (and their adjustable mountings). This system is related to the one described by Hett[4] for stereoscopic observations, although he proposes the addition of eight plane mirrors to the standard schlieren system.

The principle of this suggested system is indicated in the self-explanatory Fig. 1. In setting up the equipment, the schlieren system formed by the straight light beam between the schlieren mirrors is first adjusted in the conventional manner. The plane mirror No. 1 is then set to deflect the other light beam through the test section at right angles to the first, and the final adjustment is made with the plane mirror No. 2. The same knife edge is used for both systems.

A contribution received on July 10, 1957, from George Rudinger and Lowell M. Somers, Cornell Aeronautical Laboratory, Inc., of Cornell University, 4455 Genesee St., Buffalo 21, N.Y. This work was carried out as part of an investigation supported by internal research funds of Cornell Aeronautical Laboratory, Inc.

Since the light paths of the two schlieren systems are not equal, the resulting photographic images cannot both be exactly focused; but, with the equipment ordinarily used (schlieren mirrors of 1 ft or less in diameter and having a focal length of 4 ft or more), the depth of focus is adequate to yield two images of substantially equal definition. Another consequence of the unsymmetric arrangement is a slight difference in the size of the two images. This can easily be taken into account in a quantitative evaluation by providing a reference object of known size in the field of view.

Figure 2 is a sample photograph of a short cylinder hit by a weak shockwave (pressure ratio about 1.5). The cylinder is mounted a short distance downstream from the open end of a shock tube so that the shockwave is no longer plane. The field of the axial view is rather narrow because in the available setup the schlieren light beam was unavoidably cut off by the shock tube mounting. The primary and reflected waves are clearly seen in the two views.

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3. D. W. Holder and R. J. North, "Optical methods for examining the flow in high-speed wind tunnels. Part I, schlieren methods," *AGARDograph*, No. 23, Nov. 1956.
4. John H. Hett, "A high-speed stereoscopic schlieren system," *Jour. SMPTE*, 56: 214–218, Feb. 1951.

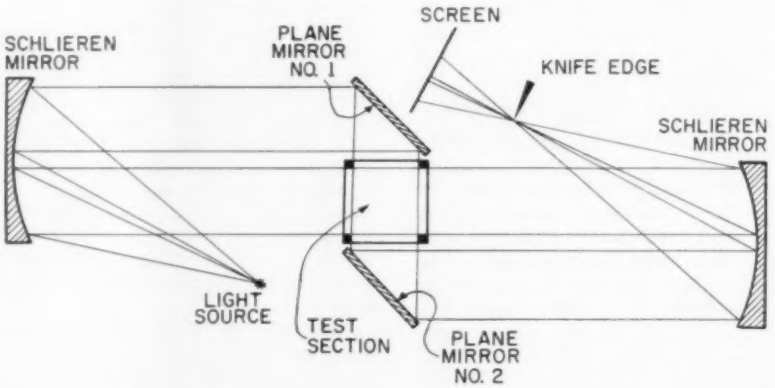

Fig. 1. Principle of the schlieren system.

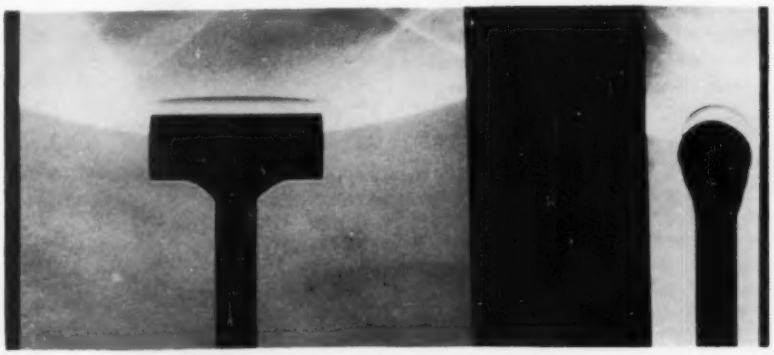

Fig. 2. Two views of a short cylinder being hit by a weak shockwave.

Effect of Gate and Shutter Characteristics on Screen Image Quality

By WILLY BORBERG

Comparative measurements demonstrating the film behavior in curved and straight gates are given. The analysis takes account of operation under high light levels with two- and three-bladed shutters.

Since publication of the paper "Modulated Air Blast for Reducing Film Buckle"[1] in 1952, tests and experiments have continued. The behavior of the film in the projector gate, under the critical conditions imposed by large-screen operation, has been further examined.

Today's projection problems are more severe than ever before, because of the continuing trend toward larger screens, greater magnifications and higher arc-light levels. The use of larger screens, whether flat or curved, makes good overall focus a very critical requirement. The increase in picture size, alone, creates demands for better picture steadiness, vertically and horizontally, but even this important factor toward screen image quality, although readily appreciated, is not necessarily the most significant. Another less obvious factor, with which we are here concerned, is the tendency for the image to move in and out of sharp focus, at a rate too fast for the eye to follow. This results in a general impression of fuzziness which cannot be corrected merely by refocusing the projection lens.

The paper referred to above explained how movement of the film along the optical axis produces this effect. Now let us further examine the consequences of film motion in the light of today's projection requirements. The high speed of modern projection lenses, and correspondingly small depth of focus, places particular emphasis on position stability of the film in the gate. The high magnification of short focal length lenses further emphasizes any out-of-focus effect due to film motion in the gate and high arc-light levels provide an environment which favors film motion.

The paper, referred to above, stated:

"Each single picture frame goes through a cycle which starts with pulldown into the aperture, proceeds through the first exposure, the flicker blade cutoff and the second exposure, and ends with the pulldown of the next frame. During the two exposure intervals the film arrests some of the radiant energy from the light source and transforms it into heat. This causes the film to buckle (or bulge) in a manner very similar to that observed in the operation of a bimetallic element. The emulsion, being more opaque than the base, absorbs energy, expands, and becomes the outer or convex surface of the bulge. The magnitude of the deformation produced varies continuously during the frame cycle and by an amount which is more than sufficient to affect sharpness of image focus.

"The emulsion side of 35mm film is toward the light source; and hence the film tends to move toward the light, away from the lens, while it is in the aperture.

"In accordance with the accepted terminology, the deformation is called *negative* when the emulsion side is convex and conversely, *positive* when the emulsion side is concave. Flat film is considered to have *zero* deformation."

Early Equipment for Studying Film Deformation

Figure 1 shows a typical curve of film displacement at the center of a frame in a two-bladed shutter mechanism. This was described in the earlier paper, and was made with the equipment shown in Fig. 2. To obtain such a curve, the film position along the optical axis is measured directly in terms of lens displacement, and a dial indicator, calibrated in thousandths of an inch, is affixed to the lens-mount for this purpose. Initial calibration for zero position on the dial indicator is made by focusing the lens to produce a critically sharp image of a conical hole in a flat steel plate, the small end of the hole being in the same plane as the emulsion contacting surfaces of the film trap. The addition of a viewing shutter and screen scope to the equipment enables observation of successive phases of the cyclicly varying film frame motion. The viewing shutter's drive-motor stator can be rotated, so that the shutter opening of about 9° can be phased in relation to the synchronously running projector.

With this stroboscopic arrangement, it is possible to view the screen image in time increments of about one millisecond through all exposure phases of successive frame cycles. The film-emulsion position during any specific phase of the exposure period can thus be established without regard to possible out-of-focus conditions during the remaining unobserved portions of the cycle. Dial indicator readings are then recorded in relation to the phase settings.

Studies made with this equipment led to the use of a modulated air blast, in which jets of pulsed air countered the tendency toward film deformation.

Improved Equipment

The pulsed air buckle correction method was tried in a number of installations and showed very promising results. However, several variables, such as film history and its condition, different light levels, and air-line pressure changes made operation unreliable and inconsistent. The air-jet noise also was considered objectionable in some projection rooms. Improved picture quality could be obtained with pulsed air, but the displacement of the perfect focus position from center to side of the frame was too large to allow the full benefit of improved definition over the entire screen.

In these experiments, good focus was sometimes difficult to obtain at the early instant of the first exposure. This poor focus condition was not due to travel ghost. There was a possibility that it could be caused by some unexplained prior film action during pulldown, the dark part of the cycle, which could not be observed with the equipment used. The stroboscopic measuring device could, of course, show only film positions while the two open shutter sectors admitted light to the screen.

A different method was therefore worked out to keep "in touch" with the rapidly moving surface of each film frame in the aperture. A mechano-electrical transducer (RCA Type 5734) was employed in the new equipment (Fig. 3). The transducer is a triode vacuum tube in which the plate is carried by a rigid shaft extending through a flexible diaphragm to the outside of the tube. An extension of this plate shaft, a feeler wire, rests on the film in the center of the aperture. Any movement of the film frame in the direction of the optical axis is thus translated into a displacement between the fixed grid and the movable plate of the triode, with a proportional change in plate current. An oscilloscope, triggered synchronously at the film frame rate, displays a curve very similar to that obtained by the stroboscope method, and, in addition, extends into the dark periods, when the shutter blades obscure the screen.

Presented on October 10, 1956, at the Society's Convention in Los Angeles by Willy Borberg, General Precision Laboratory Inc., Pleasantville, N.Y.

(This paper was received on April 25, 1957.)

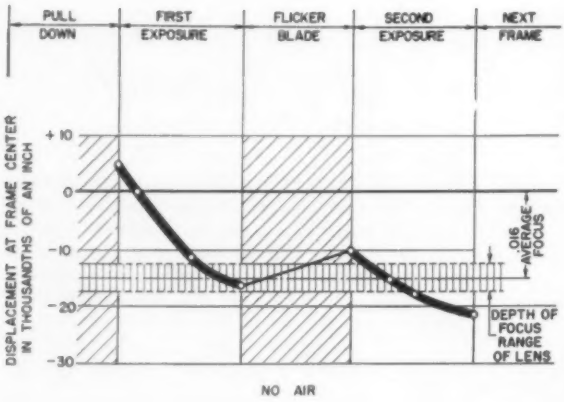

Fig. 1 Film displacement due to buckling at center of frame. No air. Straight gate.

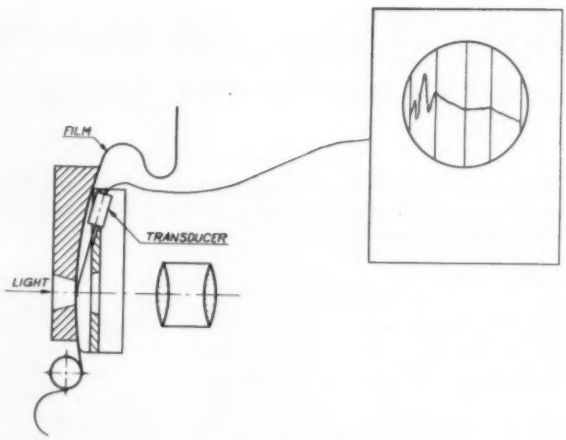

Fig. 3. Contact type test equipment used to determine continuous film buckle curves.

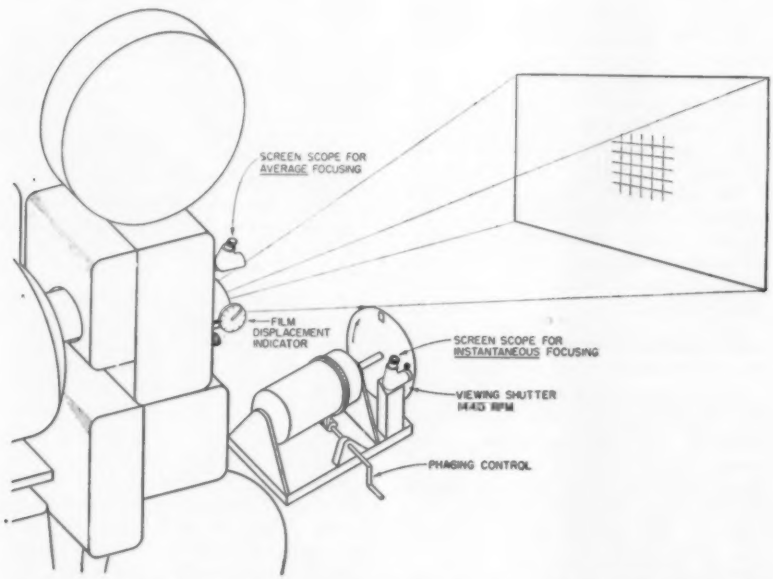

Fig. 2. Stroboscopic test equipment used to determine film buckle magnitudes and time relations.

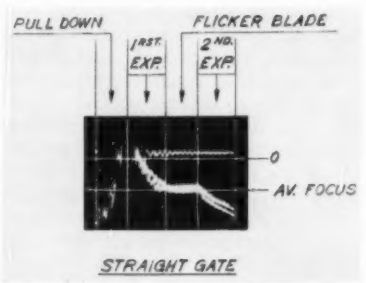

Fig. 4. Oscilloscope trace of buckle movement. Straight gate.

Analysis of Results

A photograph of the buckle movements on an oscilloscope screen is shown in Fig. 4. This is for black-and-white film in a conventional straight projector gate. It shows the first exposure, then the light cut off by the flicker blade which stops the negative excursion, until light strikes the film again with the second exposure. The upper horizontal line, just above the zero line, indicates the running film plane position without light, that is, with lamphouse dowser closed. At the left of the photograph, in the section marked "Pull Down," note the steep return toward the zero position as the new, fresh frame enters the gate. The new film frame is not at rest, however, even though no light has yet hit it, and no energy has been absorbed.

It appears as if a fluttering motion violently shakes the new film frame beyond both sides of the zero position, and this movement reaches into the beginning of the first exposure. This same phenomenon was observed by Carver, Talbot and Loomis[2] of Eastman Kodak Co. in some sections of the high-speed film on film buckling made at their laboratory and shown to the Society in 1943.

It is believed that a strain pattern exists in the length of film in the projector gate, down to the intermittent sprocket. In Fig. 5, we have tried to illustrate the pattern set up by the forces of pulldown, holdback friction and film inertia between perforation edges.

Curved Gate

The above discussed defects in the projection phase, which are responsible for a serious amount of degradation in the overall system of motion pictures, led to an investigation of the curved film gate as a means of stiffening the film and of restraining these undesirable film frame motions.

Figure 6 shows the attitude of the curved film with respect to the projection lens. It conforms with the curvature of field of the projection lens. The upper drawing, Section AA, shows the film (broken line) as it enters the curved gate at the aperture, at the beginning of the first exposure. Note that it is curled toward the lens, that is, positive.

Figure 7 shows the center of the entering frame in the curved gate about 0.006 in. above zero. By the end of the second exposure it is near 0.010 in. negative. The total excursion is only 0.016 in., as against about 0.024 in. in a straight gate under the same light conditions shown in Fig. 1. The most important improvement, however, is the fact that the average focus position of the lens is only 0.004 in. negative, in contrast to 0.016 in. with a straight gate. This average focus shift towards zero means that the center and sides of the film frames are close to the curvature of the

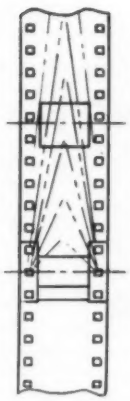

Fig. 5. Probable strain patterns in film at end of pull-down.

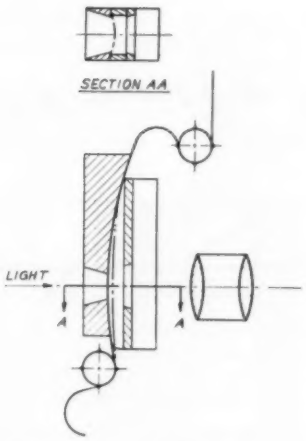

Fig. 6. Attitude of film in curved gate.

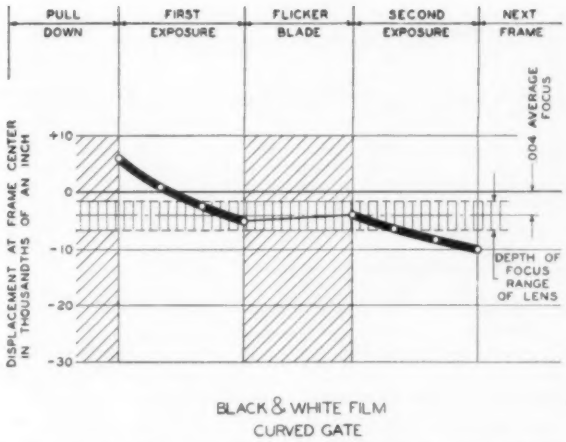

Fig. 7. Film displacement due to buckling at center of frame. Curved gate.

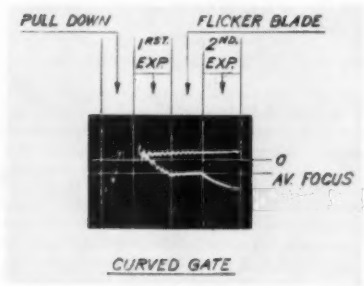

Fig. 8. Oscilloscope trace of buckle movement. Curved gate.

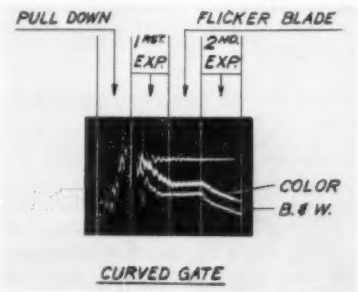

Fig. 9. Oscilloscope trace of buckle movement. Curved gate. Comparison of color film-and black- and white-film.

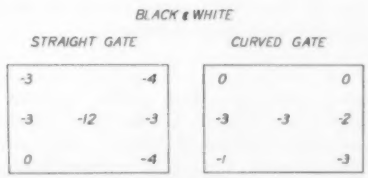

Fig. 10. Across-the-screen focus conditions. Straight gate against curved gate. Numbers are thousandths of an inch lens displacement.

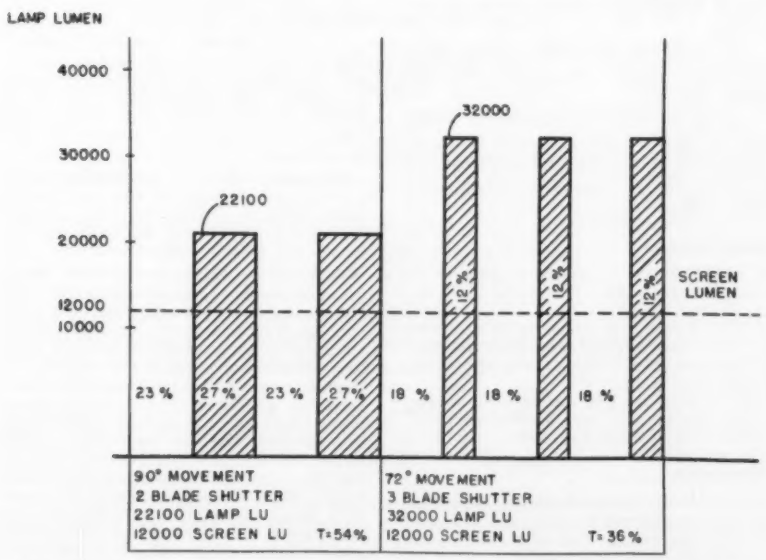

Fig. 11. Comparison of light pulses on film for same screen illumination with 2- and 3-bladed shutters.

field of the projection lens, resulting in good across-the-screen focus.

Figure 8 is a photograph which, when compared with Fig. 4, reveals another step forward. The disturbances after pulldown are found to be reduced in magnitude as well as in duration.

Figure 9 is a curve made by running a loop having color and black-and-white film patched together. Both types of film show the same pattern, but black-and-white exceeds in depth of buckle.

Figure 10 gives a comparison of focus across the screen between a straight and a curved gate with conventional two-bladed shutter projection. The black-and-white test film used here was not new; it had been run previously about 15 times. The center zone of the screen on the left shows a fairly deep negative position. The performance shown on the right, with curved gate, is far better.

Three-Bladed Shutter

In a related investigation the use of 3-bladed shutters for flicker reduction was examined; and the resultant screen image quality, as affected by buckling during this differing projection cycle, in which we have three exposures per film frame instead of two with the 2-bladed shutter, was studied.

Preview rooms, with relatively small screens at high light levels, are often equipped with 3-bladed shutters; and the 72-cycle flicker frequency gives comfortable viewing conditions. The light flux at the film gate is relatively small, so that buckling does not affect the screen image adversely. The large hard-top theaters find it desirable to do something about flicker, particularly for the front

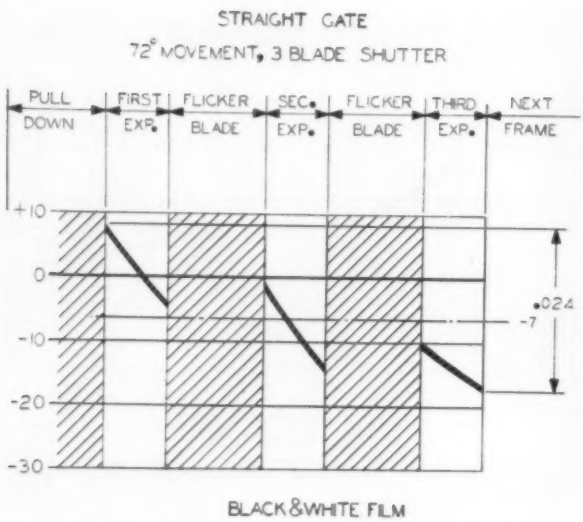

Fig. 12. Film displacement due to buckling at center of frame. 3-bladed shutter. Straight gate.

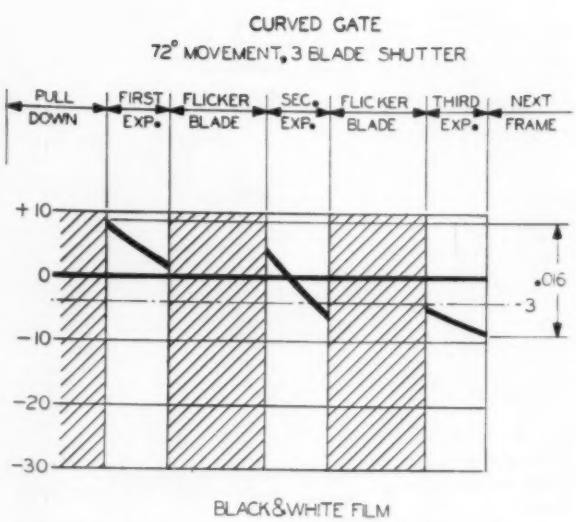

Fig. 13. Film displacement due to buckling at center of frame. 3-bladed shutter. Curved gate.

row customers. The wider viewing angle encountered in the front rows can cause peripheral flicker sensations. These houses with large screens may, however, require a light flux at the gate close to the limit of what the film can handle.

Operation with a 3-bladed shutter, and the standard 90° movement in the mechanism, would mean a reduction of light transmission from 54% to about 27%. Only a higher speed movement can offset these intolerable losses.

An experimental setup with a fast (72°) movement and a 3-bladed shutter, giving ghost-free performance, gave a light transmission of 36%. Thus, in order to have a screen light level equal to what the 2-bladed shutter produces, it is necessary to raise the light output from the projection lamp. This increases the instantaneous light and radiation intensity on the film at the aperture, but for a shorter duration per flash.

Figure 11 shows the difference in lamp output required to offset the lower transmission efficiency of a 3-bladed shutter mechanism, providing the same screen light level as formerly obtained with a 2-bladed mechanism.

Figure 12 shows how steeply the film frame buckles in each of the three exposure periods. The average focus position of the lens crosses only through the second exposure. During the first and third exposure periods the film plane is well beyond the range of depth of field of the lens. The result is not a very pleasant one on the screen.

Figure 13 shows some improvement when guiding the film through the curved gate. The screen definition is still not satisfactory. Operation with 3-bladed shutters at high light levels, with the high specific radiation in short pulses offers a new problem which awaits solution.

Conclusion

Improvements effected by the curved gate were found to be:

(1) Reduction of buckle by about 30 to 40%, which has the effect of keeping the film plane within the depth-of-field range of the lens for longer time intervals.

(2) The average focus position of the lens lies closer to the zero plane resulting in better center-to-side focus on the screen.

(3) Reduced film frame motion after pulldown; less disturbance by the strain pattern.

(4) Badly buckled films, which could not be held in focus because of buckling negatively and positively, can, with the curved gate, be shown with fully acceptable results.

References

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2. E. K. Carver, R. H. Talbot and H. A. Loomis, "Film distortions and their effect upon projection quality," *Jour. SMPE, 41:* 88–93, July 1943.
3. F. J. Kolb, Jr., "Air cooling of motion-picture film for high-screen illumination," *Jour. SMPE, 53:* 635-664, Dec. 1949.

Discussion

J. S. Chandler (*Eastman Kodak Co.*): What is the radius of curvature of the gate which was used? Was the curvature so steep as to cause trouble with depth of focus of the lens?

Mr. Borberg: The radius is about 12 inches. The gate conforms with the curvature of depth of field of the lens. The conformance, of course, is not exact for all possible lenses, but it is in the correct sense.

C. R. Daily (*Paramount Pictures Corp.*): It might be of interest to report at this time another improvement that can be achieved with cooling behind the aperture plate. It seems that when cold film meets a hot film rail, it is more subject to irregular focus than when it enters a cold rail. By using water-cooled aperture plates we very substantially reduced the temperature of the film rails — actually to the point of body temperature maximum for a Hy-Candescent lamp running at 180 amp. The stability of film running was considerably improved.

We were led to this experiment as a result of earlier work with the 250-amp transparency projectors where the stability of film focus throughout a reel was extremely important. The operator can't keep hunting out a new focus position on a transparency reel during a long take. By keeping the rails and gate structure of those machines cold, there was no drift of focus throughout a long run, and the stability of picture on the screen was considerably improved.

Now, by adding water-cooled apertures to the water-cooled trap behind the film area, there is less focus-drift throughout a whole reel than we had before. There still is a residual drift due to internal absorption of heat by the projection lens itself, but that is another problem that needs to be solved.

Mr. Borberg: I'd like to say that this curved gate is available with a water-cooled plate against which the aperture rests so that not only the aperture, but all other film contacting surfaces as well, are kept relatively cool.

Ralph Heacock (*Radio Corp. of America*): About five or six years ago we made three-bladed single shutters and were quite impressed with their operation in the laboratory. We placed them in screening rooms from coast to coast in one of the large chains, but after they had been in use for a short time we began to get complaints. As a check, we set up one projector with a three-bladed single-shutter setup, and left the other with the two-bladed single shutter setup. Then we asked the exhibitors and anyone else who came into the screening room which one they preferred. The two-bladed shutter came out ahead. Even though the three-bladed shutter had the advantage of 72-cycle shutter blade flicker, the period of white screen was so very, very short with relation to black screen that apparently the eye was interpreting the disproportionately short white screen and long black screen as flicker. From a practical viewpoint, we put back the two-bladed single-shutter mechanisms and that's the way they're still used.

With the double-shutter projectors, we had enough advantage so that this condition did not exist. But from a practical viewpoint we found

that using three blades on single-shutter mechanisms did not work out.

Have you experienced this same effect in the three-bladed shutter test that you described?

Mr. Borberg: Yes, we do recognize that the ratio between light and dark periods makes a difference in performance on the screen. As you described, the long dark period and short light pulse combination is not as pleasant to look upon as if it were the other way around.

The additional effect that we are detailing is that with the three-bladed shutter, the extreme buckle excursions during the necessarily high intensity light pulses can also give a sensation resembling flicker. It is not exactly flicker but it is unpleasant to look at and annoying, just as flicker is.

Merle Chamberlin (M-G-M): I would like to add one thing to the film-cooling experience that Dr. Daily brought up. It seems from our experiments at M-G-M that little bits of all of these improvements are needed to help out with focus. The water-cooled back plate has been very advantageous and, as all of you know, there is an attachment available on the open market for water-cooling the back plate of all projection machines. As far as the three-wing shutters are concerned, I'm inclined to agree with Mr. Heacock and Mr. Borberg. Our experiments have taught us that, with the exception of any picture having wide open ocean or bald sky, most people definitely prefer the longer illumination periods of the two-bladed shutter.

Letter to to the Editor: Developmental Possibilities of 16mm Projectors

A few comments are proffered in response to John Maurer's paper "Developmental Possibilities in 16mm Projectors" in the February 1957 *Journal*, which states (p. 50):

"Since we know that the incandescent type of lamp cannot be made to give much more than the 525 lm obtained with the present JAN-Spec projector, we must look to light sources of greater brightness . . ."

I am familiar with most of the studies made of the efficiency of incandescent lamp projection systems, all of which appear to be in agreement with the statement above. Still — I feel that there are considerations which warrant re-examination of the entire problem.

The incandescent lamp has a number of advantages over any of the alternative light sources which have been suggested for 16mm projection. It is simple, it is inexpensive, and it requires no heavy auxiliary equipment for its operation.

The demonstrations of the xenon-short-arc were impressive indeed; but the lamp is expensive, short-lived (in proportion to its cost, at least) and the auxiliary equipment required for its operation is heavy, expensive and complicated.

The zirconium arc, at least in a few experiments which I participated in, did not seem to live up to its preliminary promise as a projector light source. And I have not yet had the opportunity to work with the radio-frequency lamp, but here, again, a large auxiliary is required for operation.

So — let us re-examine the incandescent lamp situation. Incandescent lamps have a luminous efficiency of from 19 to 28 lm/w — say, for easy figuring, an average of 22 lm/w. Thus, a 1000-w lamp has a total light output of 22,000 lm. In the JAN projector, less than 550 lm reach the screen. This is an efficiency of the order of 2½%.

From an engineering standpoint, it is difficult to justify an attitude that the limit of efficiency of a system has been reached at a figure of 2 to 3%, or thereabouts.

If the efficiency of an incandescent system could be raised to only 10% — still comfortably low — the light output of the typical projector would be increased to 2200 lm, which is on a par with the projector using carbon-arc or xenon-arc equipment, and this would not seem to be an unreasonable goal.

I am not questioning the correctness of the statement that 525 lm is about the limit of light output when a projection lamp *of the present design* is used in connection with *conventional optics* (that is, the ordinary condensing lens system, with or without a mirror reflector, which in the case of biplane filaments increases the light very little, and is mainly used to improve uniformity of illumination).

What I have in mind is simply this: assume a completely free choice as far as size, shape and filament construction of a hypothetical incandescent lamp is concerned. Assume, too, a free choice of light-gathering elements, of a variety differing from the conventional condenser. It seems to me that with such an approach, we cannot yet write off the incandescent electric lamp as a projector light source, as having reached its maximum efficiency in the area of 2½%.

In short, I think that the problem lies in the area of optical design rather than the need for new and brighter light sources. And I think that the inherent simplicity and economy of the incandescent light source justify further research in the direction of increased efficiency in its utilization.

This is not entirely a matter of personal feeling. I have seen a few scattered experiments that showed considerable promise along these lines; but these were made many years ago, before the need for high powered 16mm projectors had developed, and before certain improvements in lamp construction had come about. I think this is worth thinking about, to say the least.

May 20, 1957

JOHN S. CARROLL,
160 W. 73 St., New York 23

From John A. Maurer

I agree with all that Mr. Carroll says about the desirable characteristics of the incandescent lamp. Unfortunately, it does not appear that there is any possibility of a fourfold increase of overall efficiency, or even as much as twofold.

Putting the situation as concisely as I know how to do, the maximum amount of light that any optical system can deliver to any point in an image is determined by the brightness (light flux per unit area) of the source, and by the angular aperture of the lens which forms the final image. If all areas of the projection lens are utilized, this maximum possible image brightness will actually be attained, less, of course, losses by reflection and absorption in the optical system, which seldom amount to as much as 20%.

This condition is very nearly fulfilled in the Jan Spec projector, as may be seen by inserting a pinhole mask in the picture aperture and observing with the help of a ground glass that the image of the lamp filament very nearly fills the aperture of the projection lens with the pinhole in any position within the frame area. Therefore, the only ways in which the light flux can be increased substantially are (1) to increase the brightness of the light source, or (2) to decrease the *f*-number of the projection lens. The first cannot be done with an incandescent lamp without unduly shortening its life. The second can be done only to a limited extent, since lenses of greater aperture than *f* 1.5 tend to give poor definition and, in any case, would be very difficult to keep in focus.

Like Mr. Carroll, I have seen illuminating systems using reflectors instead of condensers which come close to equalling the light output to the screen of the conventional 1000-w lamp and condenser, using lamps of much lower wattage with much smaller filaments. The efficiency of one of these systems is obviously much more than the 2½% cited by Mr. Carroll. It does not follow, however, that we could increase the wattage of the lamp used with such a reflector and thereby obtain more light than is delivered by the Jan Spec machine. The increase of lamp wattage would mean an increase in the size of the filament, and the increased light flux would be lost at the aperture plate of the projector, leaving the light output to the screen substantially the same as is obtained with the smaller lamp.

October 1, 1957

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JM Developments, Inc.
116–118 W. 29 St., New York 1.

Early Projector Mechanisms

By DON G. MALKAMES

Foreword

By Bernard D. Plakun

Don Malkames' personal collection of old projectors, gathered over the past 25 years, includes more than a hundred machines and numerous accessories, dating back to the middle 1800's.

To see and handle the material on the shelves (Fig. 1), and to hear Malkames glowingly describe the place that each piece occupied in the history of motion pictures, is a memorable experience. On picking up a small brass film can, just large enough to fit snugly into a shirt pocket, you may learn that it had once been used to carry all the film needed for an entire evening's show — which might run only 40 ft. The background hangings in the museum breathe of a past era. Billboard posters advertising the triumph of motion photography or a scene from President McKinley's inauguration (both from the year 1897) create a feeling of excitement, as though one had just been newly introduced to the miracle of pictures that move.

It is difficult to convey adequately this excitement in the pages of a book; or to show, in still pictures, the action of an intricate rotary mechanism. Willy Borberg tried to do this in a paper which he presented at the 75th Convention of this Society in April 1954. He used the machines at the museum as a valuable source of research material for his paper. During the course of this early collaboration, Malkames became interested in the possibilities of a film record, and started work on a 35mm motion picture describing the projectors in his collection. The first two reels of this film were completed in time for showing at the Society's 79th Convention in New York City on May 2, 1956. A third reel was later added, and the completed film was shown at the Society's 80th Convention.

Malkames' production was well received, and he was soon beset by numerous requests for repeat booking. Unable to meet this huge task, but unwilling to refuse, he transferred the original to National Theatre Supply, through whose courtesy the film is now being made available for showing to groups.*

Although the production was a one-man operation, without financial support, it was so well done that the narration recorded in the soundtrack could be set down here almost word for word as a finished story. All photography in the film and in the article is original, from material in the museum. The author has tried to create valuable new illustrations by avoiding widely recognized material, such as the original Edison Kinetoscope, for which numerous adequate photographs already exist.

One obvious, important omission is a discussion of Thomas Armat's work on basic projector design. The Society on two occasions has recognized the significance of Armat's work: first, when he was made an Honorary Member in 1935; and again in 1946 when he was honored with a scroll on the occasion of the 50th anniversary of his motion-picture projection demonstration in a theater on Broadway in April 1896, the first of its kind in the United States. A complete description of Mr. Armat's work was published in the *Journal* in March 1935.

Malkames regards his collection as incomplete, and is still searching for additional machines. He may, at some time in the future, prepare a story on the evolution of lighting devices leading to today's carbon arc. The museum already holds much of interest for such a story. We hope it is not long in coming.

Dates and other factual data given in the paper are supported by references in various forms. Letters from early inventors, out-of-print catalogues (i.e., J. B. Colt Catalogue, of 1894, Sears Roebuck Catalogue of 1898) and advertisements from early trade magazines were used as source material.

A contribution submitted in final form on April 24, 1957, by Don G. Malkames, 7 Plymouth Ave., Yonkers, N.Y.

*Requests for loan of 16mm or 35mm prints with optical sound may be made to: Herbert Barnett, National Theatre Supply, 92 Gold St., New York 38. The name of the group and the purpose of the showing should be stated.

Fig. 1. One wall of the projector collection in Don Malkames' Movie Museum.

During the latter part of the nineteenth century, the traveling exhibitor with his magic lantern supplied popular entertainment all over the country. Lectures on Temperance, Religion and World Travel, illustrated by lantern slides, were given in churches, rented schoolhouses, and town halls. The lecturer was also the operator. As he adjusted the light and changed the slides, he dramatically described the scenes to his audience.

Early exhibitors tried many ingenious contraptions to create movement on their screens. With hand-manipulated slide overlays, they could show what might happen to a man who imbibes too much brew (paunch expands alarmingly) or one who tries to rob a bird's nest (man and bird battle over nest). Howls of laughter resulted from such scenes as these. And for a more dramatic interlude, imagine a lonely graveyard on a sunny afternoon. As the sun sinks into the hills, the ghosts of our dear departed rise from the ground. The skeletons dance to the strains of the church organ wafting over the evening breeze. But all too soon, the night is over, and the grey dawn chases the dead back to their quiet repose.

Such scenes thrilled thousands just before the Gay Nineties. But by 1890, photography was being wedded to the rapid exposure of a series of pictures, to create the illusion of motion on a projector screen. Before the turn of the century, a complete performance usually consisted of several short films, each about 40 ft in length. These were single scenes, such as, *Empire State Express Going Sixty Miles per Hour*, or a scene of *President McKinley's Inauguration*.

An early camera built by Demeny in France made a series of rapid exposures on a revolving glass plate. After the plate was developed and printed onto another similar one, the camera became a projector by the simple addition of a light source at its rear.

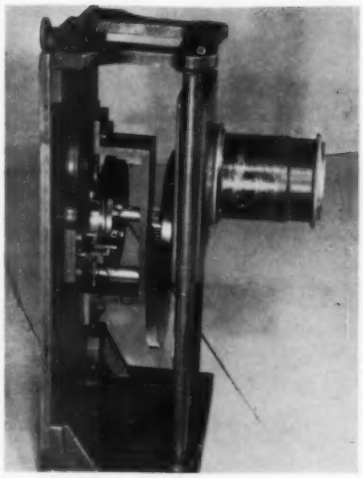


Fig. 2. The Lumière Projector.

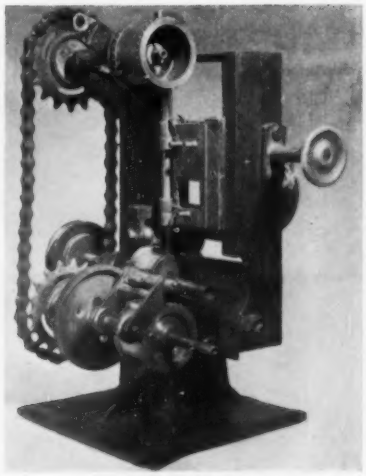


Fig. 3. Demeny Projector with beater movement.

The first motion-picture film exhibition charging admission to the general public opened in Paris, December 1895, using the Lumière *Cinematograph*. This was a combination camera, printer and projector. The intermittent movement was of the claw type and the film was perforated with only one sprocket hole on each side, per frame of film. When used as a camera, 40 ft of film was fed from a small wooden magazine on top. After exposure, it was wound into a little metal magazine, inside. When used as a projector, a small spoolholder was mounted on the top to feed the film. After projection, the film fell into a wooden box under the mechanism. No sprocket wheels were necessary for such short lengths of film. Later, the Lumière camera and projector were made as separate units. A Lumière projector was the original machine used in the Eden Musee when it opened in 1896. Figure 2 shows the projector mechanism.

An early Demeny film projector of about 1898 used the popular beater movement shown in Fig. 3. This simple mechanism gave very satisfactory results and was widely used for some years thereafter. In fact, it was used as late as 1913 in this country, in the *Kinemacolor* Projector to be described later.

The first model of the Edison projector was sold outright to the exhibitor in 1897. It became known as the *spool-bank* model, inasmuch as the film, instead of being fed from a reel, was in a continuous loop. In Fig. 4, you will note that there were no upper or lower sprockets and no means for framing. Edison used a 2-pin cam in his Geneva movement. It must be remembered that Edison's early films

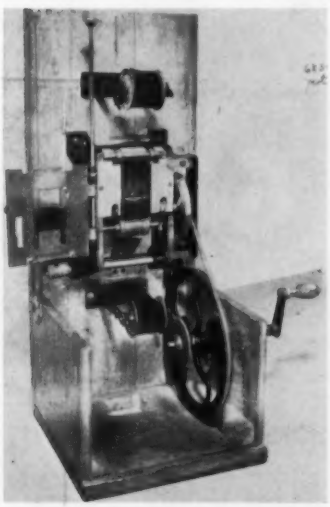


Fig. 4. Edison (Spool-Bank) Projector.

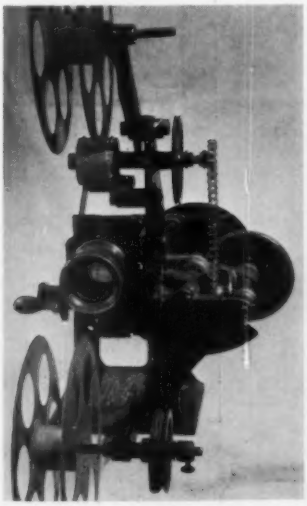


Fig. 5. The Colt Criterioscope.

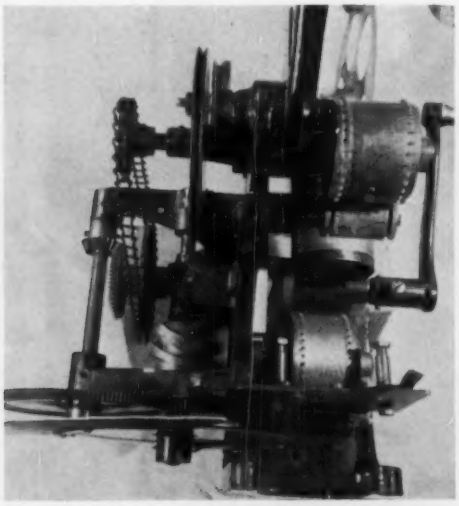


Fig. 6. Movement of the Colt Criterioscope.

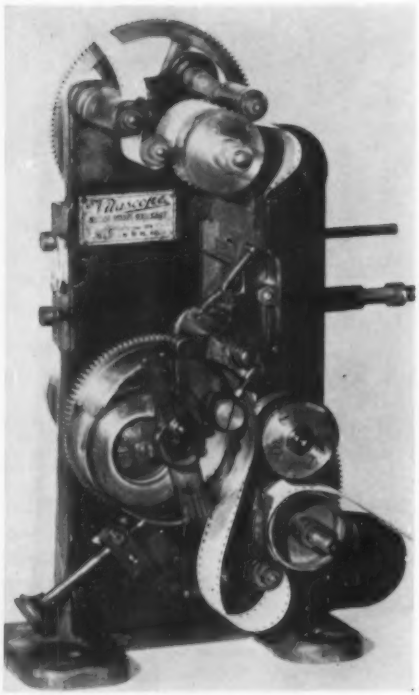


Fig. 7. German Vitascope Projector.

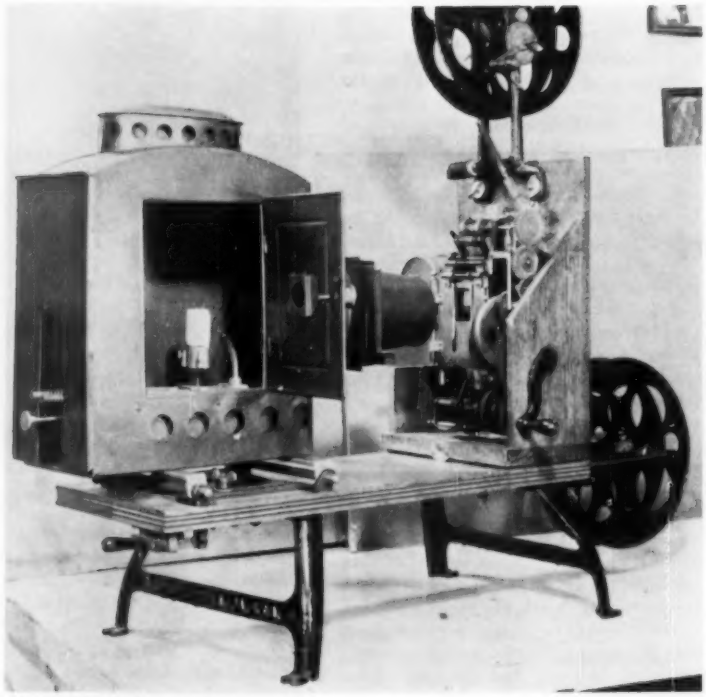


Fig. 8. The Lubin Projector.

were photographed at 40 frames/sec and the 2-pin cam allowed projection at this speed without undue wear on film or mechanism.

The Colt *Criterioscope* of this same period, built in New York City, using a rear shutter and a 40-tooth intermittent sprocket, is shown in Fig. 5. This first American rear-shutter machine might have continued in successful production but for a fire which destroyed the factory in 1900, after which production stopped. The sturdy movement in this projector (Fig. 6) reminds us of some of those used in some recent 16mm "sprocket intermittent" projectors.

Another type of movement, used about this time, periodically gripped the film between two rubber rollers to bring the picture down one frame. Several makers used this principle. A German *Vitascope*, made in Berlin by Deutsche Bioscope Gesellschaft, is shown in Fig. 7. The gate tension is relieved during the period the film is moving in the gate. The upper sprocket acts as a stop, after the film has been pulled down one frame. Framing is accomplished while running, by turning the knob on the upper sprocket, thus moving the sprocket ahead or behind in relation to the rest of the mechanism.

The Edison projecting *Kinetoscope* of 1899 ran the film into a bag or basket underneath the mechanism. Up to this time, film magazines were not used on projectors. Instead, the reel, usually holding only a few hundred feet of film, was mounted on a so-called "reel hanger" above the mechanism. This also held a

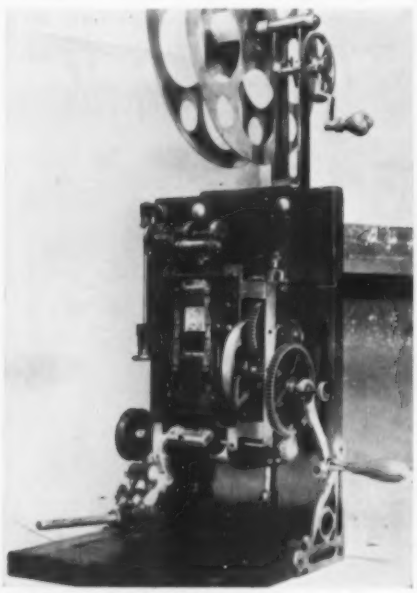


Fig. 9. Powers No. 3 Cameragraph.

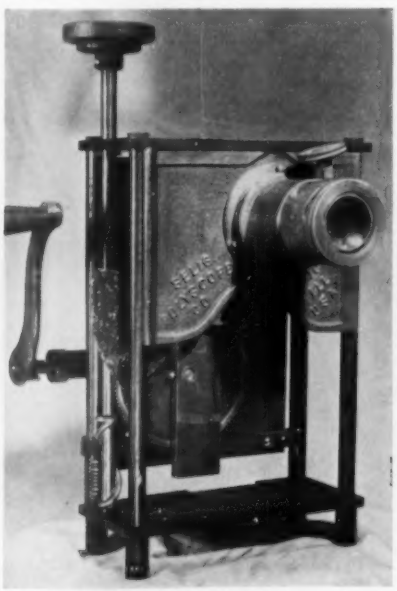


Fig. 10. The Selig Polyscope.

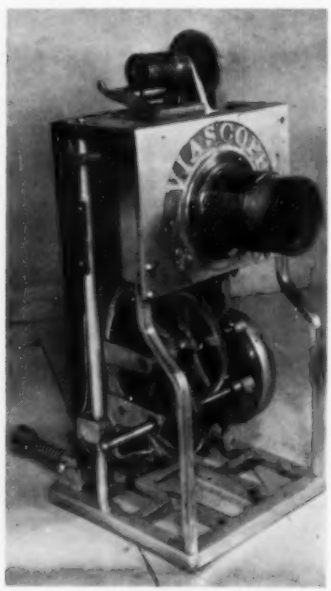


Fig. 11. Pink's Viascope.

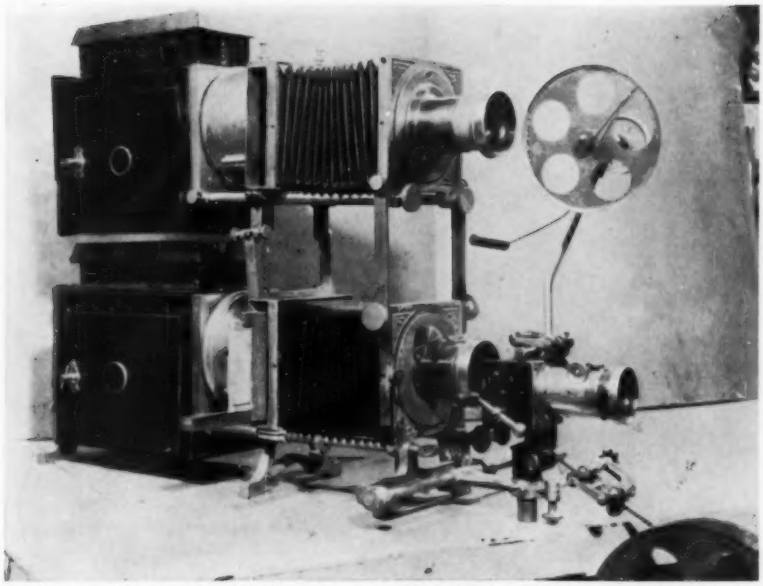


Fig. 12. The Optigraph, made by Enterprise Optical Co., used a lantern slide projector as a light source.

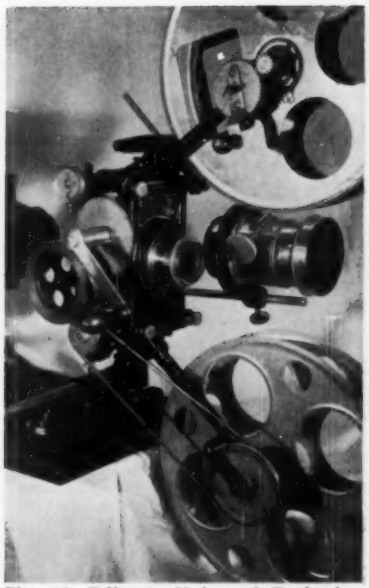


Fig. 13. Edison's Universal Projecting Kinetoscope.

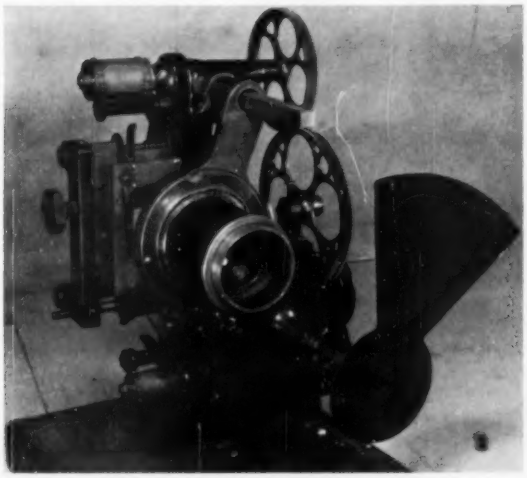


Fig. 14. Cannock's Cinematograph.

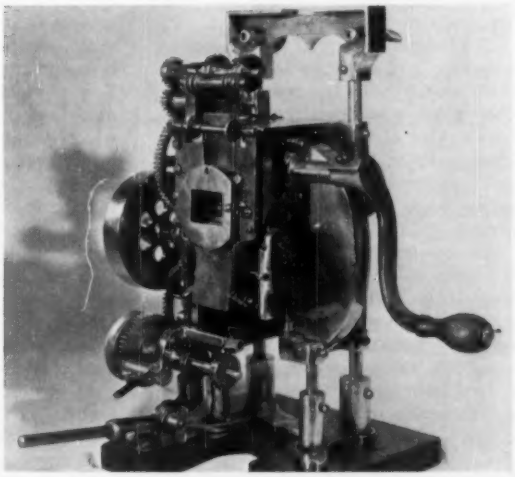


Fig. 15. Powers Cameragraph No. 4.

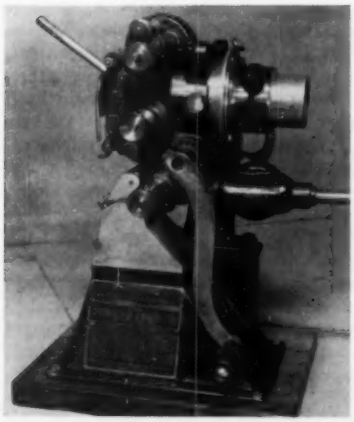


Fig. 16. Bell & Howell Kinodrome.

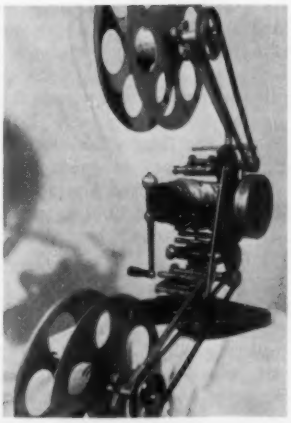


Fig. 17. The Optigraph No. 4.

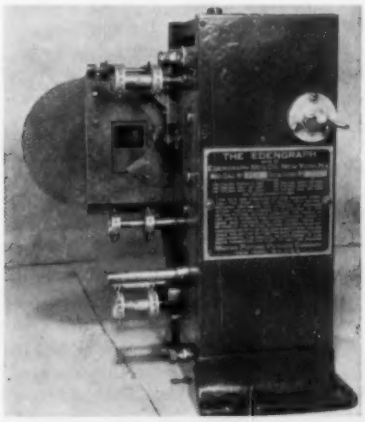


Fig. 18. Cannock's Edengraph.

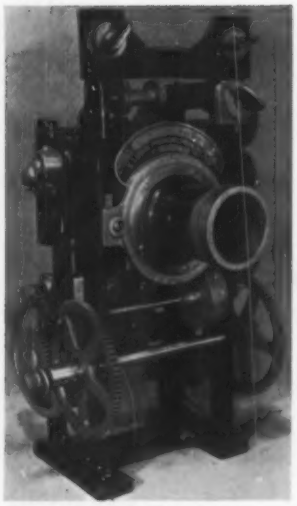


Fig. 19. Lubin's Cineograph.

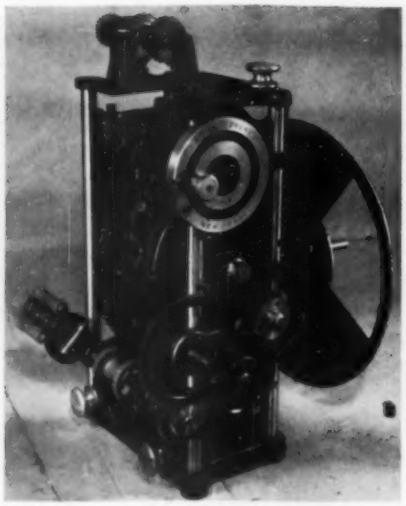


Fig. 20. French Pathé Frères Projector.

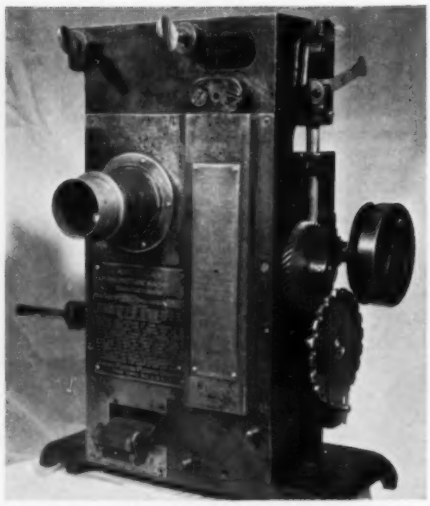


Fig. 21. American Standard Projector of 1910.

geared crank which enabled rewinding of the film between showings. The mechanism was mounted on a wooden front board and could be slid up and down for framing, only the lens and aperture plate remaining stationary.

The Lubin Projector of 1899, complete with limelight, is shown in Fig. 8. The light source will be described later. This projector was similar to that of the Edison. One of the few changes is in the framing device. Here the aperture plate and lens move up and down together. Lubin used a single-pin cam in the Geneva.

Another projector of this same period and design was the Powers *No. 3 Cameragraph*. This machine (Fig. 9) was to be greatly improved and widely used for many years to come. Powers also used a single-pin cam. Framing was accomplished as in the Edison, by shifting the entire mechanism on the wooden front board.

The Selig *Polyscope* (Fig. 10) was built by Andrew Schustek in Chicago, for Col. William N. Selig. Copied in much detail from the Improved Lumière Cinematograph, this projector used a claw movement. Note the crudely constructed screw for framing. Although these machines gave a very steady picture on the screen, they wore out very rapidly as film lengths were increased from 40 to 400 ft or more. The claw movement had six pulldown pins.

Another claw-movement projector, also manufactured in Chicago, was the *Viascope* built by John J. Pink (Fig. 11).

In 1898, A. C. Roebuck (of Sears, Roebuck fame) marketed a projection head to be used with a dissolving stereopticon which had been sold by this firm for several years. The machine shown in Fig. 12 was made under the name of Enterprise Optical Co. The projector mechanism was called the *Optigraph*. This ingenious little mechanism, not much larger than your fist, gave very acceptable projection and probably more of them were sold than all other makes combined. The mechanism was mounted on sliding rails in front of the lower lantern and could be slid out of the way when projecting slides, or dissolves could be made to a slide in the upper lantern. The Optigraph was actually the first model of the well-known Motiograph, which is still considered one of the finest projectors manufactured today. Just above the Geneva movement, between the aperture and lens, was a barrel-type shutter. Framing was accomplished by simply moving the aperture up and down. Because of its light weight, this machine became very popular with the traveling exhibitors in rural communities.

Because of the lack of electricity in most of these one-night stands, the limelight was the most popular type of light source. An intensely hot flame was directed against a stick of unslaked lime. The flame was produced by burning oxygen and hydrogen gases in proper combination. One tank, known as the saturator, supplied the hydrogen gas by vaporizing sulfuric ether. Oxygen was generated in a larger tank, where water dripped onto an oxygen-generating compound.

Inspired perhaps by the popularity of the small-sized Optigraph, Edison brought out the Edison *Universal* Projecting Kinetoscope designed by A. White in 1903. This, the first all-metal machine to come from Edison, was also designed so that it could be slid to one side to project lantern slides (see Fig. 13). Most entertainments of this period still consisted of a lecture, illustrated by slides, and interspersed with short scenes on motion-picture film. Incidentally, the sprockets, gears and bearing of most of these early machines were made of brass. Edison still retained the two-pin cam in the intermittent movement.

About 1903, Frank Cannock, who was employed as a projectionist in the Eden Musee in New York City, built the projector shown in Fig. 14 and named it the *Cinematograph*. Cannock had been a mechanic trained in the Singer Sewing Machine factory in Scotland. His mechanism probably showed the greatest mechanical precision used in a projector up to this time. This model was the forerunner of an improved machine which was later marketed as the *Edengraph* and which, still later, developed into the first model of the *Simplex*. This was, I believe, the first mechanism in which the Geneva movement was enclosed in an oil bath.

Nicholas Powers brought out his first all-metal projector, the Powers *Cameragraph No. 4*, in 1905. It immediately became very popular and thousands were sold during the next five years (see Fig. 15). The Powers *Cameragraph No. 5* had the first automatic fire shutter built in America, or, at least, so claimed the Nicholas Powers Company.

In 1907, Bell & Howell built the *Kinodrome* projector (Fig. 16) for Major George K. Spoor. This was the first machine in which framing was accomplished by revolving the intermittent, as is done in most modern projectors. Another innovation in this finely built mechanism was the double front shutter, with the disks revolving in opposite directions by using a shaft within a shaft, similar to the Century projectors of today.

The 1907 *Optigraph No. 4* (Fig. 17) used a relay condenser mounted on the gate. This model also had an arrangement for revolving the intermittent sprocket for framing. This was accomplished by a sort of sliding-screw arrangement. The Sears Roebuck catalog listed, as one of the features of this model, its ability to be operated either forward or backward. Thus, short films could be made to run more than twice their orig-

Fig. 22. Early Simplex Projector.

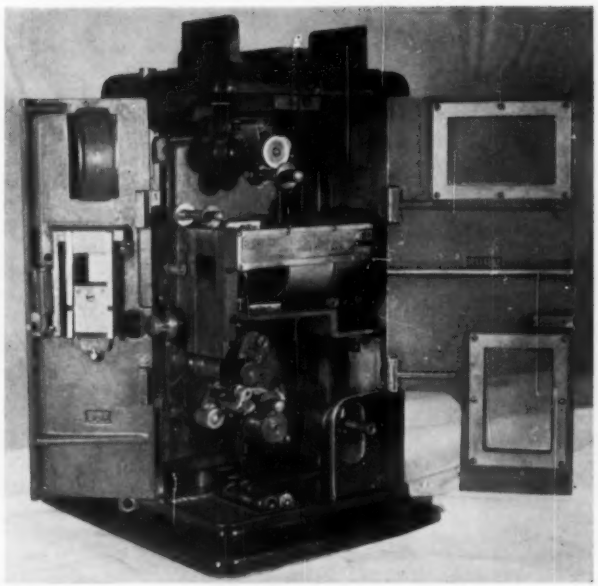


Fig. 23. Baird's Projector of 1913.

inal running time. Imagine the amusement of the audience at seeing horses going backward at full gallop; or divers springing out of the water, feet first, and alighting on the springboard! Thousands of other humorous actions were possible with the new Optigraph.

In 1908 the name of Optigraph was dropped when a new model was introduced under the name of *Motiograph No. 1*. This was the first machine having all gears enclosed. By simply pressing a button on the crank handle, the film could be rewound back onto the upper reel, ready for the next show. It must be remembered that an entire performance, in those days, consisted in most cases of only one reel of 1000 ft in length.

A double-cone shutter, mounted back of the lens and close to the aperture, gave an improvement in shutter efficiency. The completely enclosed Geneva movement slid up and down to frame, and was driven by a ball-and-socket shaft. This was the first movement that could be removed easily or replaced as a unit — a common practice today. A motor attachment could also be supplied, if desired.

In 1908, Frank Cannock introduced the *Edengraph* shown in Fig. 18. The successful years of operation of his earlier model at the Eden Musee had encouraged him to place this improved projector on the market. Although a finely designed and well constructed machine, its success was short lived. The industry was not ready to pay for the precision demanded by Cannock. Three years later, in 1908, his dream was realized when he and Edwin S. Porter designed the first Simplex.

S. Lubin's *Cineograph* (Fig. 19) was introduced as its first all-metal mechanism. It had but few improvements over earlier models.

The French *Pathé Frères* projector (Fig. 20) also enjoyed some successs in this country during this period. It was considered a well-built and sturdy machine.

The Powers *No. 6 Cameragraph* reached the market during 1909. This very ruggedly built projector was destined to become one of the most successful for many years to come. It was the first to revive the front revolving shutter which was used almost exclusively thereafter, until about 1930, on all projectors. It introduced adjustable tension springs in the gate. However, the intermittent movement was the greatest innovation in this newest Powers Projector.

A five-to-one pin cross movement of entirely new design was used. It gave longer exposure without imposing strain on the film or the mechanism. Many old timers, today, still wonder why this movement hasn't been revived in some modern projector. Instead of a pivoted idler roller on the top sprocket, there were two small rollers at a fixed distance from the sprocket, similar to the design of many 16mm projectors today. A shoe was used on the lower sprocket, instead of a roller. The pin cross movement was mounted inside the flywheel.

A short time after the first of these machines was used in theaters, and after many complaints from users, the Powers Company announced that, due to the fact that the industry was changing over to the complete use of noninflammable film, several elements in the design were found to be impractical and would be changed at no cost to the purchaser. The changes consisted of replacing the upper and lower idlers with the type formerly used, as well as enclosing the intermittent in an oil-tight casing. But it was to be more than 40 years before the industry would finally adopt noninflammable film.

In 1910, the *American Standard* projector (Fig. 21) reached the market and was quite popular for several years. In fact, it is claimed that for a short time there were more American Standards in use in Broadway houses than any other make.

In 1911, a new trend in projector design took place. The first *Simplex* had arrived. This mechanism (Fig. 22) is so well known to the industry today that it is unnecessary to describe its many advantages over other machines of that period. It was the first completely enclosed mechanism with center frame bearings. It had means for adjusting the revolving shutter during operation, a new style of sliding gate instead of the former hinged types, a new type of fire shutter and governor, and a precision-focusing and lens-mount adjustment.

The Edison *Model D* was a modernization of its old design made by adding a front shutter and semi-enclosure of the gears. This model used flanged sprockets and is believed to be the first mechanism to use side guides for the film passing through the gate.

In 1913, Motiograph brought out its *1A* model which had a front shutter, double flywheels and other improvements.

The *Baird* projector, manufactured in New York, was also announced in 1913. This machine (Fig. 23) was closer to the general appearance of a modern projector than any others of that time, and was still offered for sale as late as 1922. It had the first lamphouse of proportions

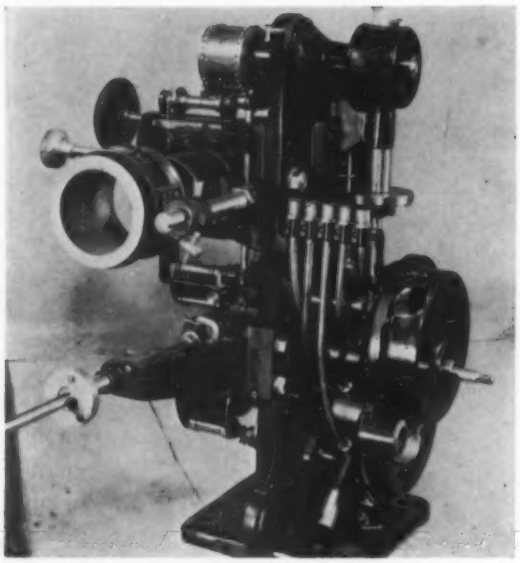


Fig. 24. The German Ernemann Projector.

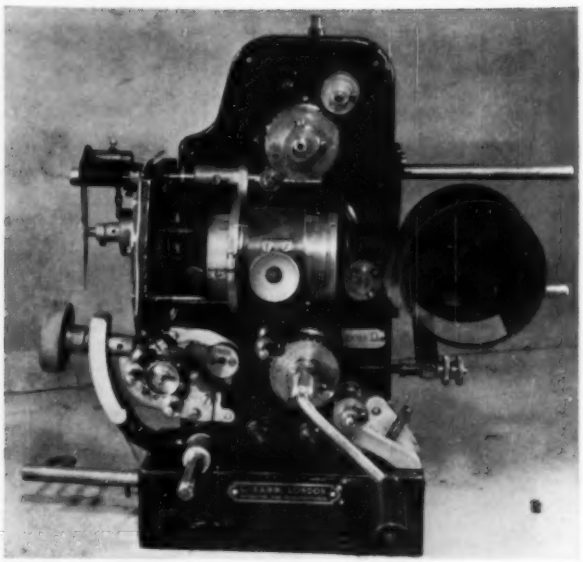


Fig. 25. The English Kamm Projector.

such as we presently use, a heavy iron pedestal, 3000-ft magazines of heavy construction, and a mechanism designed for simplicity of gearing and construction. The particular Baird projector illustrated saw service from 1915 to 1923 in the Hersker Theater in West Hazelton, Pa. When it was demonstrated in the theater lobby, prior to installation, as an example of the latest and best in projection equipment, it made a certain schoolboy play truant to examine it in awestruck wonder. That schoolboy is now the author of this paper.

Figure 24 shows the 1912 model of the German *Ernemann*. Here some attempt was made at a centralized oiling point. As in all foreign projectors, the film side of the mechanism was in the open, and 32-tooth feed and take-up sprockets were used. When using short-focus lenses, they could easily be moved out of the way to open the gate.

The English *Kamm* projector (Fig. 25), with its front barrel shutter, was also of an unusual design as compared with American projectors of that day.

The *Kinemacolor* projector of 1913 reverted to the, by then, seldom used Demeny beater movement (see Fig. 26). The color wheel behind the aperture projected alternate frames through red and green filters at about 32 frames/sec. The results on the screen were really the first semisuccessful presentation of actual color motion-picture photography. These projectors were, of course, used with road shows rather than permanently installed, although they would project standard black-and-white prints by removing the revolving color filters.

In 1921, Motiograph brought out the *Model F*. By this time all American projectors had enclosed mechanisms, center frame bearings and front revolving shutters.

Even the Nicholas Powers Company designed its *Cameragraph No. 7* with completely enclosed mechanism featuring automatic upper and lower loop setters. Before this machine (Fig. 27) was

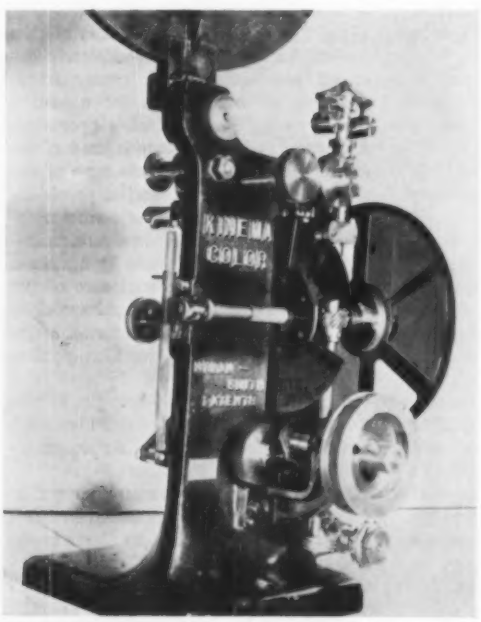


Fig. 26. The Kinemacolor Projector.

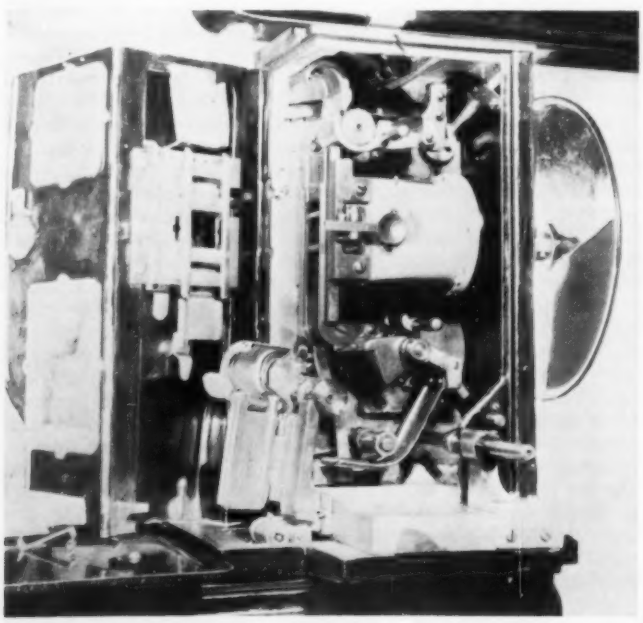


Fig. 27. Nicholas Powers Cameragraph No. 7.

placed on the market, the original company merged with International Projector Corporation. Then, with the coming of talking pictures, the esteemed Powers mechanism quietly disappeared from the field.

Perhaps the greatest single improvement in projector design during the 1920's came from Germany. In 1925, the German AEG projector introduced the conical rear shutter. This shutter made possible the greatest light efficiency, coupled with the utmost heat elimination. It was the forerunner of the shutters found in the most modern projectors of today.

In 1928, Motiograph equipped its machines with rear cylindrical shutters. With the introduction of sound-on-film, the reduced picture aperture size, plus the perforated sound screens, made an increase in arc amperage necessary. Rear shutters became very desirable. One designed by Bassen and Stern reduced the heat on the film, as well as supplied a stream of cool air around the aperture.

The *Super Simplex* of 1930 was designed with a rear disk shutter. This model could also be supplied with a turret to hold three lenses. By changing lenses during projection, the screen could be enlarged suddenly for spectacular sequences of the picture.

We have seen many of the early projector mechanisms developed during the first 35 years of our industry. But there were 25 more years of development and expert engineering before we had the excellent projectors of today, with their efficient optical systems, foolproof automatically lubricated mechanism, film take-ups which provide uniform tension of 7 to 8 oz, whether using a 2-in. hub, or taking up 5000 ft of film, conical rear shutters, operating less than 1 in. from the film aperture, water-cooled aperture plates and, of great importance, the recently introduced curve gate which gives the utmost in picture sharpness on the screen. This gate greatly reduced buckling and damage to the film image, which has proven so troublesome since the introduction of the various wide-screen techniques.

Yes, we've come a *long* way from the Edison spool-bank Kinetoscope of 1897.

news and reports

Combined Forces Make History at Bartlesville

Fame is a chancy thing, perhaps especially in motion-picture and television engineering. A combination of forces (and a vacuum) may have put Bartlesville, Okla., into our history as a Famous First in motion-picture distribution, with the goal: every home a boxoffice; every home a first-run movie theater.

Last summer the financing finger of Video Independent Theatres, Inc., pointed at Bartlesville (pop. 30,000), and on September 3, when the delighted citizens turned on their television receivers to view *Pajama Game*, via the new (coaxial) Telemovie system, they assured the town at least a paragraph in all future histories of the development of television. The monthly subscription rate of $9.50 became effective October 1.

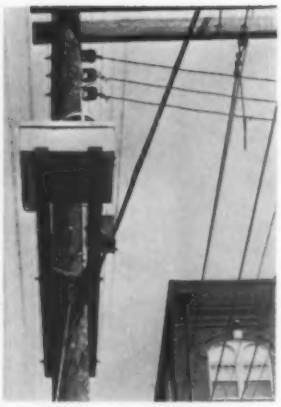
Although Jerrold Electronics Corp., designers of the Telemovie cable and distribution plant, object to the term "experiment" and describe the innovation as a "full-fledged business venture," a number of questions are being asked in the columns of the trade papers and daily newspapers that must be answered before the most optimistic reporter can let himself go and call the Bartlesville project "the dawn of a new era." The questions most frequently asked concern (1) economics, (2) legalistic aspects and (3) the relationship to broadcast pay-TV.

The Economy

Areas of uncertainty seem to be encountered in even the most informed discussions of financing and the conclusions that might be drawn from the known facts are contingent on the solution of problems that have not, as yet, been clearly defined.

On September 3, a total of 472 installations had been completed in Bartlesville and 271 more were awaiting extension of trunk and feeder lines. Henry S. Griffing, President of Video Independent Theatres, admitted at a recent press conference in New York that this figure had no real significance but "it indicates a lively beginning for Telemovies in the first test," he said. He added that within the year he expected to reach 2000 subscriptions which would represent 40% of the homes with

Studio interior of the Telemovie Center at Bartlesville, Okla. It is in quarters converted and renovated in the "old" Lyric Theatre. Most of the equipment was made by General Precision Laboratory, Inc. (Photo by Herman's Studio and Camera Center, Oklahoma City, Okla.)



Amplifiers supplied by Jerrold Electronics Corp. are housed in weatherproof boxes and installed on poles at regular intervals through the distribution system.

System technicians "tap" a cable drop from the main trunk into the subscriber's home.

A switch is attached to the back of the receiver to enable a subscriber to watch either regular off-the-air TV programs or Telemovie films.

TV sets and bring the venture to the "break-even" point.

Any evaluation of the potentialities of Telemovies based on the Bartlesville test must take into consideration that Bartlesville is hardly in all respects what may be called a typical American town. For one thing, it has an average family income of over $6,000 and there is virtually no unemployment. One sales management report has rated the effective buying income of Bartlesville as $62.3 millions with a per capita income of $2,276 and income of $7,006 per family. There are four theaters in the town, all owned by the Telemovies promoter, Video Independent Theatres, Inc.

At the New York press conference questions were raised about the probable cost and feasibility of installing the cable and feeder lines in large cities and towns where the installation problems might be far different from those encountered in Bartlesville. As Mr. Griffing pointed out, there is no answer to this and similar questions except in terms of the specific situation.

The Jerrold Electronics Corp., developers of community antennae systems and the Cable Theatre System have also spoken on the economics. A frank explanation and analysis of the economics of Telemovies was presented at the Society's Convention at Philadelphia, October 5, by Donald Kirk, Jr., of Jerrold, in a paper entitled "Economic Considerations in Closed-Circuit Television System Design." Mr. Kirk said there are two unknowns of major importance: "First," he said, "we don't know how much the American public will pay. . . and second, we don't know how much [cable theater] will cost." A trial market analysis, he indicated, would throw light on the first factor. In discussing the second, he suggested a method for arriving at a figure representing the combined costs of installation, equipment and maintenance.

The Law

The questions concerned with legalistic hazards and with broadcast pay-TV are closely related. The advent of the various forms of broadcast pay-TV which included scrambled programs, decoding devices, coin boxes and "silent pictures" was immediately followed by a roar of disapproval from many Congressmen, and a strong hint that the Federal Communications Commission could well turn thumbs-down on pay-TV, if indeed it had the authority to act at all. As time went on and it became more apparent that promoters of pay-TV were running into stormy weather, the attention in the trade shifted to cable TV which, it was believed, might be exempt from FCC ruling.

Mr. Griffing has repeatedly insisted that Telemovie is by no means in the same category as pay-TV. He reiterates that it is nothing more or less than a new form of motion-picture exhibition and is no more a threat to exhibitors than drive-ins. Far from being a threat, he regards it as a shot in the arm for the ailing industry and he describes it as a means for survival. There are, however, a few hints that this view is not necessarily shared by all concerned.

Broadcast Pay-TV

While Telemovies may have slipped in because of the vacuum caused by long waiting for decisions of the FCC on toll-TV, wired movie enthusiasts have been warned in an ominous and well-publicized statement by FCC Chairman John C. Doerfer: "Anyone who envisions huge profits in wired-TV had better look over his shoulder. That warm feeling of a 'golden' glow may merely be the hot breath of regulation."

When asked to comment on Mr. Doerfer's statement, Mr. Griffing's response was immediate and vigorous. He said that he found the expression most extraordinary and completely inaccurate. That rather than envisioning any "golden glow," the promoters of Telemovies were willing to chance losing money on the venture in a gamble for the survival of motion-picture exhibition. He stressed the word "survival" and said that the whole project was undertaken in an effort to bring exhibition out of the slump into which it has fallen. "The success of Telemovies will simply mean that there will be three forms of accepted exhibition — conventional, drive-in and Telemovies," he said. He explained that one of the major aims of Telemovies is to bring in the potential audience which now infrequently patronizes the movies.

Chairman Doerfer's statement was made on September 14. On September 18 the FCC issued cautiously worded instructions as a first step toward possible eventual authorization of pay-TV on a trial basis. The announcement covers only the "acceptance and consideration of applications from present or proposed television stations requesting authorization to conduct trial subscription TV operations." If an application is accepted, the try-out would extend over a three-year period "on a limited basis" and under "controlled conditions." March 1, 1958, is the earliest date on which action will be taken on applications. The FCC is not committed to grant any applications and the initial ruling "does not constitute adoption of a final order."

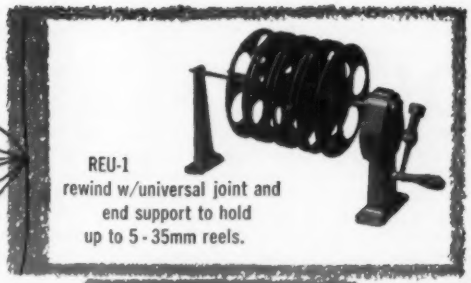
The question of jurisdiction has loomed large in Congressional discussions preceding publication of the FCC statement. Doubts were expressed as to the extent of FCC authority in the matter and the question was raised as to whether it properly came under Agency or Congressional jurisdiction. The FCC statement may serve to define the extent of its authority but by no means does it rule out the possibility that Congress may during the next session approve a bill outlawing pay-TV.

One of the most vigorous opponents of pay-TV is Rep. Emanuel Celler (D.,N.Y.), Chairman of the House Judiciary Committee. He is the author of a pending bill that would have the effect of preventing any further FCC action in this matter and would place the authority in the hands of Congress. Considerable support is expected for his bill when Congress reconvenes.

Pay-TV received its first serious attention

HF

REWINDS *and* ACCESSORIES



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from the "big three," Zenith, Skiatron and Telemeter, each of whom favored some form of scrambled programs with a decoding device. Telemeter developed a coin-box system (described in the August 1953 *Journal*, pp. 183-194), reportedly in the hopes of side-stepping the FCC. Another ingenious device, involving the separation of picture and sound was promoted by TeleGlobe. With this method, the set-owner would not pay for the picture but would be charged for the sound. The Bi-Tran system developed by Blonder Tongue Laboratories bases its coded TV on a "dual channel" multiplexing device which, the firm reports, does not interfere with free programs.

The rapidly mounting opposition in Congress and the, at best, tepid FCC statement have served to dampen the enthusiasm of pay-TV sponsors. Spokesmen for the "big three" are admittedly pessimistic. In the opinion of a Skiatron official, pay-TV has been "killed for at least five years."

The Technology

When the spotlight is turned away from the economic and legalistic aspects of Telemovies and onto the technical aspects, the picture is a much happier one. There is no question of the success as a technical innovation..

Telemovies in Bartlesville originate in what was formerly a 600-seat VIT-owned theater. It now houses two complete film chains, each comprised of two 35mm film projectors and two vidicon cameras, a multiplexer, master monitor, and control console. Most of the studio equipment was made by General Precision Laboratory Inc. The projectors are Simplex 35mm XL theater machines specially modified for television with a 3-2 shutter and intermittent movement to synchronize the standard film projection frame rate with television standard. The adaptation of CinemaScope and VistaVision to the aspect ratio of home TV screens is accomplished by electronically altering the sweep of the film camera by pushing pre-set buttons on a monitor console. Comments from viewers indicate that the adaptation is entirely satisfactory.

Other than Jerrold and GPL, firms whose products are used in the project are Adler Communications Laboratory, power supplies; Pye Ltd., sync generators; Tel-Instrument Corp., bar-dot generators; Muzak tape recording, and Gray Research and Development, Inc., slide projectors. In addition to installation equipment, Jerrold also supplied modulators.

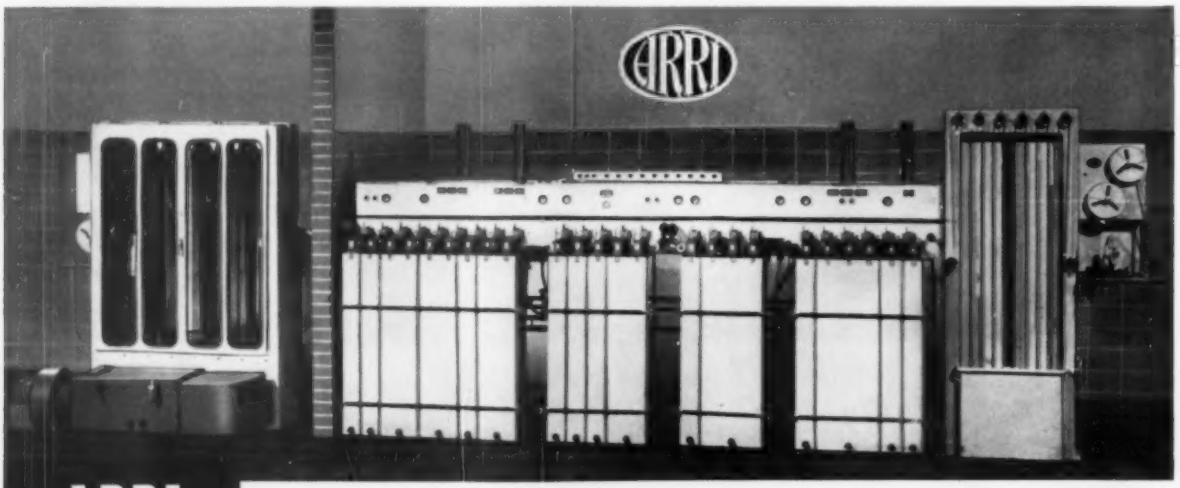
The Bartlesville program, although considered separately from pay-TV, came about in response to the same economic factors that influenced it. Interest is especially keen in both the economic and technical aspects of Telemovies. Mr. Kirk's paper will be published in an early issue of the *Journal* and other papers are expected which will describe certain equipment made especially for the test and will explore the technical possibilities inherent in the trend toward new fields of development. —*R.H.*

Industry, Education News

Industrial Film Production is the title of a new course being given this Fall by the Fullerton Evening Junior College, Fullerton, Calif. The course will be conducted by Jay E. Gordon, supervisor of motion pictures at Autonetics, a division of North American Aviation, Downey, Calif. Content of the course is aimed at the management and professional levels of film-making as well as the semi-technical areas. Topics which will be covered include the organization of a film production unit, production of films using commercial facilities, budgeting a film and scheduling photography.

Robert S. Burnap, Manager of Commercial Engineering, RCA Electron Tube Division, Harrison, N.J., was honored at a luncheon celebrating his 40 years of service with the company. Mr. Burnap began his career as an engineer with the Edison Lamp Works of the General Electric Co., Harrison, in 1917. After returning from military service during World War I, he was appointed Manager of the Engineering Section of the Lamp Works in 1925. He has held his present position since 1930. He is a Fellow of this Society, and also a Fellow of the Institute of Radio Engineers and the American Institute of Electrical Engineers.

Raymond L. Garman, Technical Director of Research and Development, General Precision Laboratory, Inc., Pleasantville,



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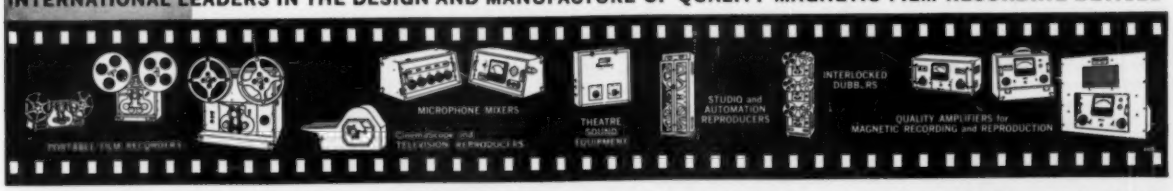

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N.Y., has been elected Chairman of the Board. Prior to his present appointment, he had the post of Executive Vice-President of GPL. Dr. Garman is a Fellow of the Society.

Announcement has also been made of the election of James W. Murray to the post of President and Chief Executive Officer of GPL. In making the announcements Herman G. Place, President of General Precision Equipment Corp., parent company of GPL, cited GPL's achievements "over the past 12 years," mentioning especially automatic airborne navigation systems.

Carlos H. Elmer has joined the staff of Traid Corp., 17136 Ventura Blvd., Encino, Calif., photographic instrumentation specialists and special representatives for Bell & Howell Co. Since 1947 he has served as a photographic and technical information supervisor at the U.S. Naval Ordnance Test Station, China Lake, Calif., the Navy's largest rocket and guided missile research and development center. He is a Fellow of this Society and the author of several technical papers and has contributed portions on high-speed photography and instrumentation for the Progress Report since 1953.

Outside the realm of this Society's field many know him for his still color photography, particularly commemorated by the February 1957 *Arizona Highways* with 12 pages in color and a text and many monochrome pictures giving as Carlos's prescription for contentment: photography. Along with his new work he is now touring the western states making scenic color photographs with a unique new panoramic still camera.

The Tenth Annual Conference on Electrical Techniques in Medicine and Biology will be held November 6 to 8 at the Sheraton-Plaza Hotel, Boston. The meeting is sponsored by the Instrument Society of America, the American Institute of Electrical Engineers, the Boston Chapter of the Professional Group on Medical Electronics of the Institute of Radio Engineers, and the Medical Physics Group of Boston. The purpose of the Conference is to bring together electrical engineers, physicians, biologists, electronic instrumentologists, radiation physicists, physiologists and others to discuss the latest electrical and electronic techniques in biology and medicine and to arrange symposia on current problems. Three morning sessions and one evening panel discussion are scheduled. Afternoons are left free for tours to laboratories in the area.

Obituary

Dr. Donald MacKenzie, 69, died August 20 at Albuquerque, N.M. A former member of this Society, he was cited in "The History of Sound Motion Pictures" by Edward W. Kellogg (June 1955 *Journal*) for his pioneer work on soundtracks. Early in 1922 he became interested in the possibilities of the light valve and carried on much of the study of film emulsions, exposures and developments. He held BA, MA, and PhD degrees from Johns Hopkins and worked at various times with Western Electric Co., Bell Telephone System and Electrical Research Products. While with Western Electric he made early studies in speech and hearing upon which his improvements in light valves for recording on film were based. From 1952 until his retirement in January 1957, he served as Patent Manager of Sandia Corp., Albuquerque. The company is a subsidiary of Western Electric Co., and prime contractor to the Atomic Energy Commission. Organizations other than this Society of which he had been a member include American Physical Society, Society of Automotive Engineers, Acoustical Society of America and American Institute of Physics.

current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion-picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer vol. 38, June 1957

Making the Aerial Shots for "The Spirit of St. Louis" (p. 366) *A. Rowan*

Techniques of Hollywood Cinematographers (p. 368) *J. Henry*

Careful Pre-planning Means Better 16mm Pictures, Greater Profits (p. 372) *L. Allen*

Filming Crashes, Fires, and Disasters (p. 376) *F. Foster*

How Cine Technicians in India Produce Special Photographic Effects (p. 379) *D. Patel*

Special Effects for the Amateur (p. 380) *R. N. Martin*

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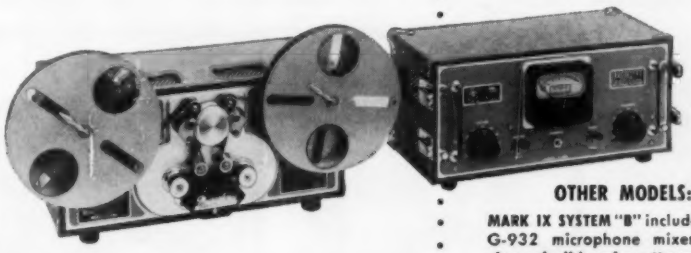

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Cine Photography after Dark (p. 382) *J. R. Oswald*
Success with Sound Recording (p. 383) *A. Taylor*

vol. 38, Aug. 1957
Video Tape—A Threat to Films? (p. 504) *A. Gavin*
8mm Movies for TV (p. 512)
Filming the Mayflower Story (p. 514) *F. Harris*
Jet-Age Photography from a Bomber (p. 516) *B. M. Dresner*
Home Movie Theatre Deluxe (p. 518) *W. W. Gebhart*

British Kinematography vol. 30, June 1957
Milestones in British Studio Techniques (p. 151)
Photo-Electronic Aids to Photography (p. 165) *J. D. McGee*

vol. 31, July 1957
The Use of 16mm Striped Film for Local Production of Fundamental Education Films (p. 3) *N. Spurr*

Film Technikum vol. 7, July 1957
Konstruktionsmerkmale der Schmalfilm-Projektoren (p. 212) *H. Weise*
Möller—Anamorphote für CinemaScope und für Amateure (p. 234)

International Photographer vol. 29, June 1957
Technirama (p. 5) *J. V. Mascelli*

International Projectionist vol. 32, June 1957
Film Standards for Picture and Sound (p. 7) *R.A. Mitchell*
Film Damage: Its Causes and Preventive Measures (p. 11) *J. Holt*
Motion Pictures and Color TV (p. 13)
Optical? Magnetic? Now Compatible (p. 14)
From the British Viewpoint (p. 15) *R. H. Cricks*

vol. 32, Aug. 1957
For a Brighter, Flickerless Picture (p. 7) *R. A. Mitchell*
Some Methods for Solving Focus Drift Problems (p. 13) *J. Holt*
Super Cinex Improvements (p. 14)
Ernemann "Anterior Gates" (p. 17)
Floating Screen Considered for all Todd 70mm Shows? (p. 24)

Kino-Technik vol. 11, May 1957
Der Wissenschaftliche Film—ein Helfer des Forschenden Menschen (p. 164) *A. R. Michaelis*
Die Technik der Hochfrequenz-Zeitlupe mit Lichtblitzen (p. 167) *Thorwart*
Die Röntgen-Kinematographie mit dem Bildverstärker (p. 169) *H. Uhl*
Die Aufgaben der Filmtechnik im Fernseh-Sendebetrieb (p. 171) *K. E. Gondesen*
Aus dem Angebot der Deutschen Kinotechnischen Industrie (p. 179)

vol. 11, June 1957
Film und Filmtheater in neuen Dimensionen (p. 196) *G. Haufler*
Versuch einer Bewertung der einzelnen Filmverfahren (p. 200) *H. Tümmel*
Neue Tontechnik ergänzt die moderne Bildwiedergabe (p. 202) *H. Drechsel*
Die optischen Bedingungen der Breitwand-Verfahren (p. 205) *R. Vetter, Jr.*
Der Stand der Wiedergabetechnik im Filmtheater (p. 208) *G. Haufler*
Physiologisch-optische Probleme bei der Bildbetrachtung (p. 214) *H. Schober*

vol. 11, July, 1957
Der Einsatz des 16-mm Films in Industrie und Werbung (p. 236) *K. Matzner*
Filmaufnahmen in Körperhöhlen nach französischem Prinzip (p. 239) *L. Debierre*
Entwicklungsprinzipien im Bau von Schmalfilmkameras (p. 243) *H. Weise*
Fassungen für Objektive an Schmalfilm-Kameras (p. 245) *Vetter*
Halb- und vollautomatische Blendenregler an Kinokameras (p. 247) *H. Weise*

vol. 11, Aug. 1957
Die Richtfunktechnik bei der Fernsehübertragung (p. 272) *E. Dietrich*
Die Umschalttechnik auf den Fernseh-Richtfunklinien (p. 275) *K. Dittmann*
Das Ausland und seine Fernseh-Übertragungstechnik (p. 280) *E. Dietrich*
Zweistreifen-Sendungen nach dem Pilotton-Verfahren (p. 283) *A. Wackerl*
Startmarkierung und Anlegeverfahren jetzt Automatisch (p. 286) *J. Schürer*

Mechanical Engineering vol. 79, Apr. 1957
A Nonintermittent Film Projector (p. 345) *O. Wittel* and *D. G. Haefele*

Motion Picture Herald vol. 208, Sept. 14, 1957
What Better Projection Means in Terms of the New Techniques (p. 6, Better Theatres Section) *G. Gagliardi*

Photographic Science and Engineering
vol. 1, July 1957
Factors Affecting the Recognition of Small, Low-Contrast Photographic Images (p. 15) *R. S. Barrows*
A Temperature-Compensating Device for Photographic Processing (p. 23) *D. J. Howe* and *J. A. C. Yule*

Radio & TV News vol. 58, Sept. 1957
Pictures on a Flat Panel (p. 55) *K. Butler*

Technirama Special—Supplement to Kinematograph Weekly vol. 481, May 30, 1957
This Has Boosted the Cinema's Earning Power (Technicolor Technirama Camera) (p. iii)
Delrama—The Technirama Camera Anamorph (p. x)

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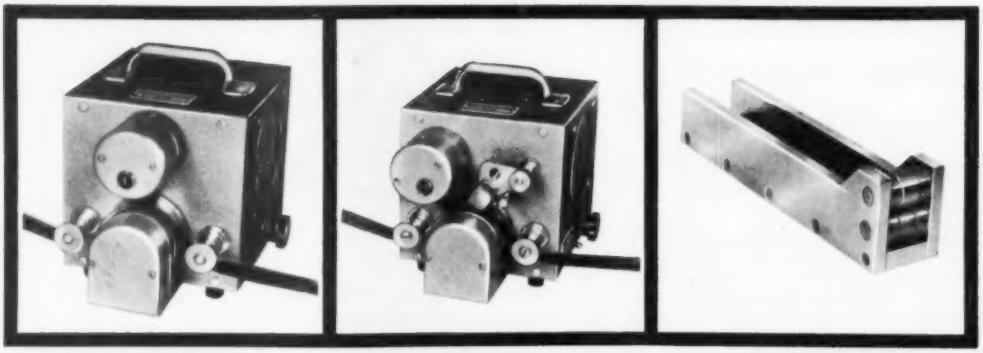

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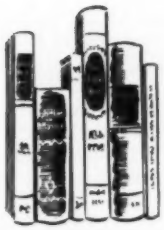

books reviewed

Proceedings of the Third International Congress on High-Speed Photography

Edited by R. B. Collins. Published (1957) Butterworths Publications, Ltd., 88 Kingsway, London, W.C.2. Distributed by Academic Press, Inc., 111 Fifth Ave., New York 3. 9¾ by 6-in. 417 pp. Illus. Price $13.00.

The valuable technical content and outstanding organization of the Third International Congress on High-Speed Photography are both evidenced in the 417 pages of the published *Proceedings*, now available to workers in the field.

Upon arrival at the Congress site in the Air Ministry, New Government Offices, Whitehall, London, on 10 September 1956, delegates to the Congress either had with them preprinted copies of the technical papers, or received them at that time. Thus, it was possible to confine the technical sessions to discussions of the papers which had already been examined by the delegates, saving much valuable time.

The published *Proceedings*, therefore, are based upon the preprinted papers, with the addition of the verbatim discussion that followed the announcement of each paper in session.

Other important additions found in the *Proceedings* include a most noteworthy opening address by Lt-Col. Pierre Naslin, of the Laboratoire Central de l'Armement, Paris, entitled "Continuum and Quanta." His broad perspective in analyzing historical developments in the field of high-speed photography, and in relating the overall aspects of communications and control systems on the one hand, with cinematography on the other, provided an excellent basis for commencing this meeting, and makes interesting and valuable reading today.

In addition, the *Proceedings* contain the thorough and incisive review of the Congress delivered on the closing day by Dr. J. S. Courtney-Pratt of the University of Cambridge; a review of the excellent Exhibition by its organizer, Dr. A. R. Michaelis; and a review of the film exhibits that were presented concurrently with the technical sessions, the latter review being prepared by E. G. Hill, Dept. of Scientific and Industrial Research, London.

The fields of interest covered in the *Proceedings* are indicated by the following listing of sessions, with the number of papers in each session given in parentheses:

1. Flashlight Sources (4)
2. Flashlight Sources (5)
3. Image-Splitting and Image-Sampling Techniques (5)
4. Inertialess Shutters (4)
5. Application to
   - A. Biology and Medicine (1)
   - B. Machine Analysis (2)
6. Application to Ballistics and Explosives (4)
7. Instrument Aids (3)
8. Photographic Materials (4)
9. X-Rays (3)
10. Film Evaluation (3)
11. Schlieren and Interferometric Techniques (4)
12. Rotating Mirror Cameras (7)
13. Medium Repetition Rate Cameras (3)
14. Application to Aerodynamics (3)
15. Application to Hydrodynamics (5)
16. Review Papers (3)

While it is difficult to comment upon papers in a limited review article, mention should be made of two papers that especially impressed the reviewer at the time they were delivered at the Congress. They are: "Ultrasonic Fractography," by F. Kerkhof, University of Freiburg im Breisgau, describing the use of the interaction of ultrasonic waves with propagating fractures in glass to obtain fracture propagation rates in two or three dimensions; and "The Dependence of Interpretation on Photographic Technique in Fluid Kinetics Research," by R. P. Fraser and N. Dombrowski, High Speed Fluid Kinetics Laboratory, Dept. of Chemical Engineering, Imperial College of Science and Technology. In the latter paper, the authors have demonstrated in a most elegant manner the radically different results obtained by photographing

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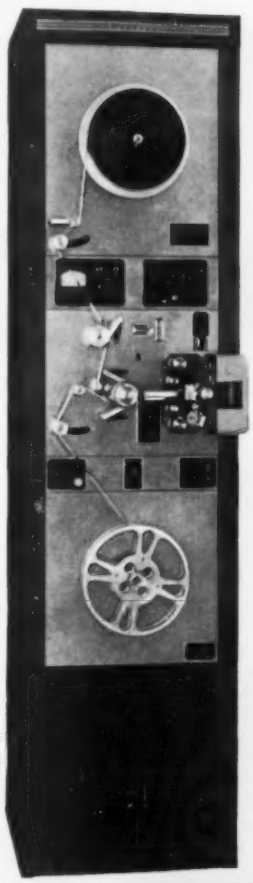

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the disintegration of liquid sheets at varying exposure times and by means of several different types of lighting.

The volume is well-edited and thoroughly illustrated. Its excellent readability and handsome appearance reflect the outstanding work performed by the editor, R. B. Collins, and his staff of assistants. Most significant however, is the fact that this volume was published only a few months after adjournment of the Congress, thus making the work of the Congress available almost immediately. It deserves a place in the library of any serious worker in the field of high-speed photography and its applications.

In conclusion, a quotation from the very able summary by Dr. Courtney-Pratt may be in order. He stated, in commenting upon the opening address by Professor Naslin:

"This comprehensive view and correlation of the principles underlying high-speed photography will allow us to develop new techniques with greater surety, as it provides a better means of assessing how good a proposed technique is; or of deciding whether the possibilities are such that there is no hope of a great improvement in it although we might effect some technical improvement. We will know too whether what we are trying to do is to make a real improvement, to the eventual advancement of the science, or whether we are really trying to re-group or re-shuffle the parameters so that the particular technique we have chosen is at its most suitable for our own particular subject."

The vast bulk of the information developed in the *Proceedings* of the Third International Congress on High-Speed Photography is of the type that should contribute to the real improvements which Dr. Courtney-Pratt has mentioned.—*Carlos H. Elmer*, 410 B Forrestal St., China Lake, Calif.

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Selling Color to People

By Faber Birren. Published (1956) by University Books, Inc., 404 Fourth Ave., New York 16. 219 pp. Illus. Graphs. 10 by 6¾-in. Price $7.50.

Here is a different kind of book about color. It provides answers to commercial color problems, and in so doing it points up the kinds of commercial pitfalls to which the injudicious use of color can lead. These pitfalls, as Mr. Birren shows, are far from obvious.

Selling Color to People recognizes that there are color trends, and that these trends are not simple to anticipate. Matter-of-fact polls are not of much value, for the reason that the public may not be sure today what it is going to like tomorrow in the way of color. And color trends are not easy to force. A consumer may be susceptible to education as far as product design and utility are concerned, but he seems to remain emotionally stubborn about color. As Mr. Birren says, it is as if the public, wandering in quest of new delights, gropes about with its mind more or less open and undecided. Then, unexpectedly, people gather around the same color wants, and how or why they got there may not be clearly known.

Selling Color to People is an extremely interesting book. Embracing, as it does, strategies of merchandising with color, color and human personality, cycles of color trends, along with many other commercial facets of color, this should be an extremely useful book for business executives, sales managers, stylists, designers and advertising men, and even Mr. John Q. Public, if he wants to learn how color can and will be used on him and for him.

The title, *Selling Color to People*, seems to me to be misleading. Before reading Mr. Birren's book, I had the impression that he thought people had to be sold on color, and so had written a book telling how this could be done. But people do want color—in fact, they demand it, as Mr. Birren states repeatedly in his book. How to understand and to anticipate an unknowing public is what Mr. Birren is really telling us how to do.

I found one mild disappointment in this book — namely that the subtractive or printing primaries are called "red", "yellow" and "blue," rather than magenta (red-blue), yellow (red-green) and cyan (blue-green) as they should be. Regrettably the use of "red" and "blue" in this loose fashion for magenta and cyan undoubtedly acts as a bar to a more widespread understanding of the principles of subtractive color mixture.—*Wilton R. Holm*, Photo Dept., E. I. du Pont de Nemours & Co., Parlin, N.J.

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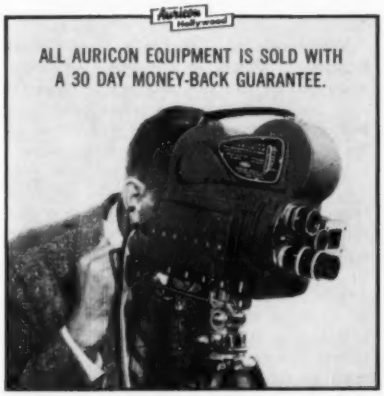

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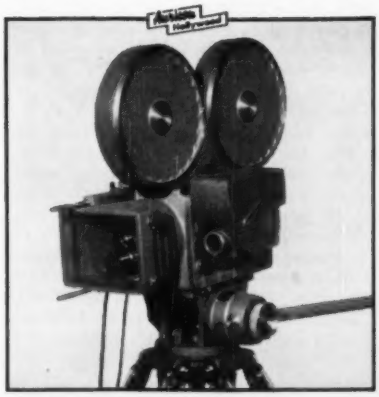

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Proceedings of the National Electronics Conference Vol. 12

Published (1957) by National Electronics Conference, 84 E. Randolph St., Chicago 1. i-xiv + 1095 pp. (incl. numerous charts, diagrams and tables) + 31 pp. contents of previous vols. 6 by 9-in. Price $5.00.

After eleven consecutive years of publication, we have begun to accept the annual volume of NEC Proceedings as one of the inevitable concomitants of living, like death and taxes; however, we should not permit this familiarity to cause us to minimize the value of the yearly product. It remains consistently an excellent job of publication, covering a wide range of topics, and containing a large amount of new, significant, and useful information.

The variety of subjects covered, in the more than 100 papers contained in this volume, makes it a difficult, perhaps impossible task for any reviewer to do it justice in a short article. The material ranges from general papers on such topics as "The Space Satellite Program" by J. P. Hagen, through eminently practical papers on topics such as "Selenium Rectifiers for High Voltage" by V. Wouk, and "A Description of Plated Printed Wiring Boards and a Comparison of Their Performance Characteristics With Those of Etched Boards" by J. J. Schoebel and D. E. Yost, to more complex and theoretical papers on "Stability Criterion for Digital Feedback Control Systems" by J. Tou, "Transient Analysis of Discrete Networks by Dirichlet Transforms" by A. E. Sabroff and T. J. Higgins, and "Network Design by Use of Modern Synthesis Techniques and Tables" by L. Weinberg.

There is clearly something for everybody here, and it is generally well presented and of good quality. While the number of papers specifically concerned with television is small, with only one, entitled: "A Survey of TV System Parameters Applied to Closed-Circuit Industrial TV" by F. R. Pike, actually mentioning television by name, many of the papers contain information as useful to the television and sound engineer as to any other electronic engineer. A few papers of this sort which might be mentioned are "Analysis and Design of Transistor Bias Networks" by S. K. Ghandhi (which appears almost unchanged in a new transistor text of which he is co-author), "Evaluation of High Powered Outdoor Sound Systems" by R. W. Benson, and "Building Reliability Into Cathode Ray Tubes" by R. K. Reichenbach.

This reviewer might summarize his comments by stating that while the book is something of a hash, the ingredients are of high quality, and, if the reader will pardon a slightly mixed metaphor, this is not a case of too many cooks spoiling the broth. The price has been maintained at $5.00 over the years, while the number of pages has almost doubled over the contents of the first volume. Under these conditions it is certainly to be recommended, using the jargon of certain consumer research organizations, as a Best Buy.—*S. Sherr*, General Precision Laboratory Inc., Pleasantville, N.Y.

The Lion's Share

By Bosley Crowther. Published (1957) by E. P. Dutton & Co., 300 4th Ave., New York 10. 320 pp. Illus. 5½ by 8-in. Price $5.00.

While reading *The Lion's Share* one is impressed, almost to the point of being appalled, by the vast amount of research and documentation that must have preceded this pared-down, tight account of the giants who created a baroque, supercolossal world and whose enormous vulgarities, wild eccentricities and fabulous luck have come legend, symbolizing one aspect of the American Dream. As the author explains in the foreword, he set out to write of the "growth, grandeur and grotesqueries of American films" and to do so he tells the story in terms of the people who made them. The quiet, understated style of the book is in effective contrast to the flamboyance of the material and the deft little touches of wit come with the flash of a rapier.

Mr. Crowther who, if not the dean of motion-picture critics, is certainly one of the more grave and erudite, has selected the story of Metro-Goldwyn-Mayer and it's parent, Loew's Inc., to represent the whole gaudy era. Viewing his subject with a clinical although not necessarily an unsympathetic eye, the author tells of the great personalities of the film world in a mood of cool detachment. If the book can be said to have a "hero" other than the MGM lion it is Irving Thalberg whose brilliant portrait is shaded with a touch of pathos.

In an especially interesting chapter, happily entitled "The Crash of Sound," the author credits Lee de Forest's miracle "device" of the audion, invented in 1906, for the rapid development of sound after its early beginnings. In a significant comment, the author says, "The notion. . .that *The Jazz Singer* was a miracle that touched the screen one fateful evening in 1927. . .is an unfortunate impression — particularly in these days when the screen is undergoing an evolution comparable to the prolonged change to sound. For the factors that brought the transformation were actually extensive and involved, beyond the manipulation of any individual will. They included the forward push of science in the new electronic age that was as inexorable and compelling as it was in the period of invention when the movies were born."—*R.H.*

Responsibilities of Film Producers and Sponsors is a 40-page publication issued by the Association of National Advertisers, Inc., 155 E. 44 St., New York 17, for the information and benefit of both sponsors and producers of nontheatrical films. The report discusses five phases of film-making: Planning, Script, Production, Prints, and Distribution. The report is presented in a two-column format with the sponsor's responsibilities outlined in one column, parallel to the column describing similar responsibilities of the producer. An appendix contains examples of contracts and a glossary of terms used in the report. It is available to nonmembers of the ANA at $5.00 a copy.

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Magnetic Recording Handbook

By R. E. B. Hickman. Published (1956) by George Newnes, Ltd., London. Distributed by Transatlantic Arts, Inc., Hollywood by the Sea, Fla. 5½ by 8¼-inl 176 pp. 109 Illus. Price $5.00.

A wealth of practical information on tape recorders used in Great Britain is included in this book. More than half of its 176 pages and 109 illustrations describe British machines which range from pocket models to fourteen-channel airport installations. Drum-type and disk-type dictation machines are included. A chapter on special methods and applications deals briefly with FM, PM, and boundary-displacement recording, "stereosonic" tapes, the RCA system of television recording, etc.; however, computers, data and telemetering, and other non-sound applications are not treated in detail.

Sound film equipment is limited to the GB-Bell and Howell Model 630D Magnetic Optical 16mm Projector, and to the Cole Sound Magnetic Adaptor which can be installed in Victor 16mm projectors. Professional 35mm equipment is considered beyond the scope of this book.

Chapters on practical recording and on maintenance and servicing give useful information for the professional recording technician, as well as for owners of tape recorders who want to get the most out of their equipment.

The brief history of magnetic recording is apparently derived from literature available to the author, who gives due credit to British and German work; but is not aware that high-frequency bias was used in the USA before World War II, that present-day high coercivity tapes were developed here, and that (with one or two early exceptions) American recording machines did not stem from wartime German designs but from independent development.

The chapter on theory is also brief, but gives a general background for one who is interested in practical aspects. A bibliography lists over 100 references for further study.

Appendixes include an opinion on the legality of home recording of broadcast programs, CCIR frequency response characteristics for interchangeable tapes, and standard spools and hubs for magnetic tape.

All in all, this *Magnetic Recording Handbook* duplicates little of what is available in the USA literature, and is a valuable addition to a complete recording library.—*Marvin Camras*, Physics Research Dept., Armour Research Foundation of Illinois Institute of Technology, 3440 South State St., Chicago.

Das Agfa Magnettonband, Seine Anwendung und Prüfung (Agfa Magnetic Tape, Its Application and Testing)

By K. A. Mittelstrass. Published (1957) by VEB Wilhelm Knapp Verlag, Halle (Saale), East Germany. Paper cover. 85 pp. 34 Illus. 5¾ by 8¼-in. Price DM 3.50.

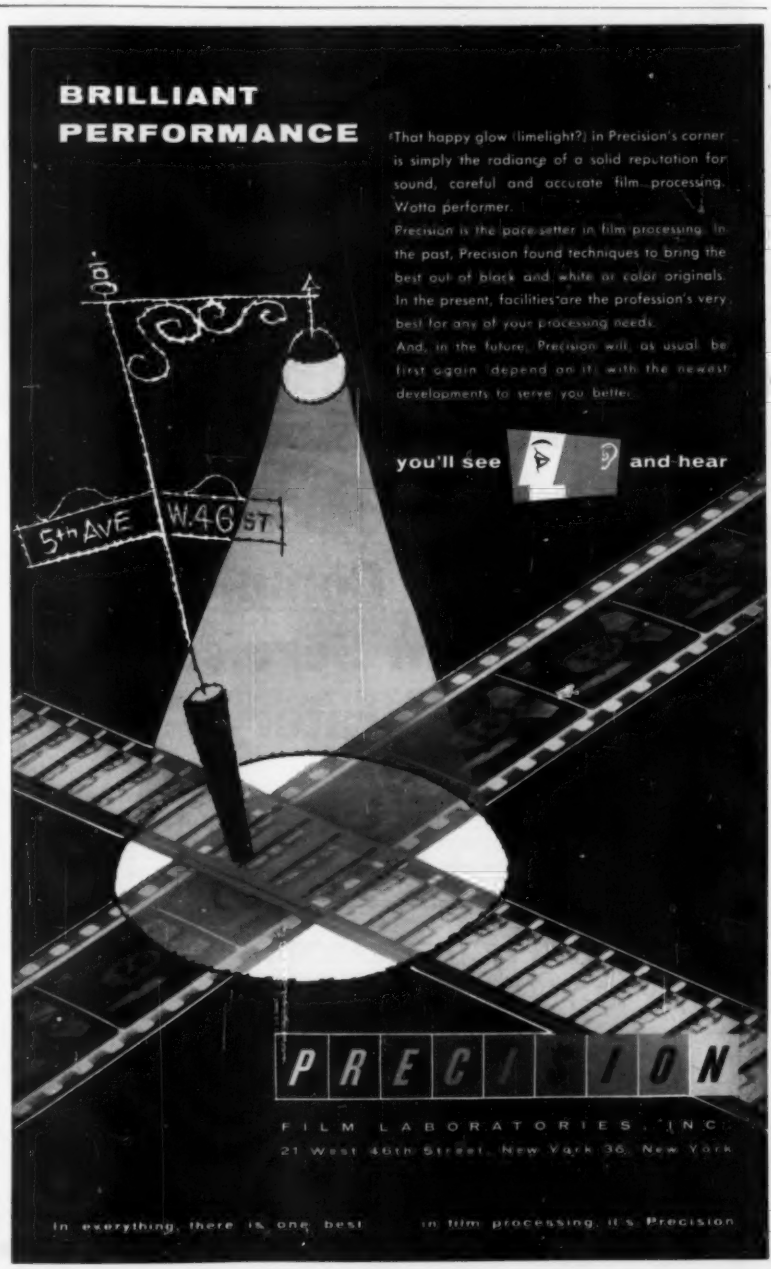
This booklet (in German) outlines the fundamentals of tape recording, and describes in detail the many tests which are applied to magnetic tape.

Emphasis is placed on operational tests which include sensitivity, uniformity, frequency response, distortion, noise, interlayer crosstalk, etc. These are made on a special test rig equipped with signal-generators, filters, and meters. Although equipment for magnetic testing is mentioned, numerical values for the magnetic properties of Agfa (or any other) tape are not stated.

A pre-recorded test tape available from Agfa is described. This is accurately recorded at 90° ±3′ for azimuth alignment, and has test frequencies ranging from 40 to 12,000 cycles for checking the playback response of machines at 19 cm (7½ in.) per second.—*Marvin Camras*, Physics Research Dept., Armour Research Foundation of Illinois Institute of Technology, 3440 South State St., Chicago.

Technisches Kinotaschenbuch, published by Zeiss Ikon, Kiel, Germany, is a 4 by 6-in., 155-page pocketbook containing every type of reference material for projectionists. It is published only in German, and is made available by Zeiss Ikon to its customers on a complimentary basis. Among the contents are relevant standards, measurement conversion tables, circuitry and all kinds of informative matter on lenses, lamps, filters, projector mechanisms, sound systems and projection practice in general.

This little booklet is the work of Herbert Tümmel, of Zeiss Ikon ("Design of projection rooms for German motion-picture theaters," *Jour. SMPTE, 66:* 123–126, Mar. 1957). Mr. Tümmel is also the editor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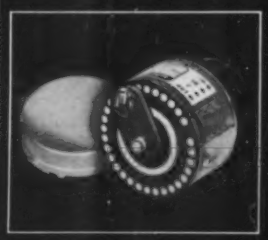

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of the well-known technical periodical put out by Zeiss Ikon, *Bild und Ton*, which is published in English as *Picture and Sound*.

Lexikon der Kinotechnik

Die Theorie und Praxis der Filmwiedergabe, by Alfred R. Schulze. Published (1956) by VEB Wilhelm Knapp Verlag, Halle (Saale), East Germany. 6 by 8-in. 508 pp. 48 illus. 91 tables. Price: DM 16.

This encyclopedia is intended primarily for engineers, projectionists and theater managers and purports to cover all the available information on the construction and operation of motion-picture equipment, including mechanical troubles and their causes. With the technological expansion of the motion-picture industry it has been found necessary to include many terms borrowed from the areas of acoustics, electroacoustics, electrotechnics, optical and magnetic sound, and optics. The alphabetically arranged articles cover all types of film processes and handling, film standards, maintenance and repair problems and projection practice. An appendix contains the text of the official regulations governing the industry in East Germany.

Cinematheque de Belgique, publisher of the *World List of Film Periodicals and Serials* in 1955, has announced the availability of a 56-page *First Supplement* which completes the main volume. The book is bilingual (French and English) and mentions 131 new film periodicals and 245 corrections and additions to the former notes.

It contains a general index of titles, an index of subjects and an index of countries. Price is $1, which can be sent by postal money order or Unesco book coupons (crossed checks also accepted) to the publisher at Palais des Beaux-Arts, 23 Ravenstein, Brussels.

1957 Film Daily Year Book

Jack Alicoate, Editor-in-Chief. Published (1957) by Film Daily, 1501 Broadway, New York 36. 1280 pp. illus. 6 by 9-in. Price $15.00. (The price includes a years' subscription to the publication *Film Daily*.)

The *Film Daily year books*, published annually since 1918, are perhaps the best known and most comprehensive reference sources for persons connected with or interested in the film industry. This year's volume includes every conceivable item of information that might be useful to industry personnel or to editors, writers and researchers. A few of the listings include theaters, industry personnel, equipment manufacturers and publications. Another helpful feature is the listing of Los Angeles and New York telephone numbers of producers, studios, publications, associations and major hotels, restaurants, air lines and railroads.

The book also contains copyright information, analysis of foreign markets and informative articles by authorities on various phases of film production.

Fundamentals of Optics
Third Edition

By Francis A. Jenkins and Harvey E. White. Published (1957) by McGraw-Hill Book Co., 330 W. 42d St., New York 36. vii + 637 pp. Illus. 6 by 9-in. Price $8.50.

This is the third edition of a book which has acquired a reputation in the twenty years of its existence. It is designed as a text for an advanced undergraduate course in optics, but has also extensively served as a useful reference on general optics.

In its first form the book covered only physical optics. The second edition added geometrical and quantum optics. The third edition keeps the same general subject matter, but derivations have been simplified and a few new items of current interest have been introduced.

The topics in geometrical optics include reflection and refraction phenomena, thin and thick lenses, mirrors, ray tracing, effects of stops and aberrations, and a brief survey of optical instruments.

In physical optics the topics cover the various phenomena of interference and diffraction, of absorption, scattering, polarization and reflection, a discussion on the electromagnetic character of light, electrooptic and magnetic phenomena, and the velocity of light.

The book is especially useful because a number of topics are treated unusually well. Examples of this are the discussions on third order lens aberrations (which are usually much too sketchy in treatises at this level) and on the effects of stops (which again are rarely included). The photometry of optical systems represents still another example of fuller treatment than usual.

On the other hand it must be noted that the discussion on eyepieces is quite conventional. As in most treatments, even moderately advanced, it fails to indicate the primary reason for use of the field lens, namely to reduce loss of light toward the edges of the field of view. In discussing the achromatization of the Kellner eyepiece with Porro prisms, the aberration characteristics of the latter are left in a very sketchy state.

It is recognized that a compact volume like this must omit some material, but the motion-picture engineer will regret that there is no discussion of projection optics, particularly that condensers are ignored. Microscope condensers are also omitted.

A very desirable feature of the book is the frequent reference to both older and current literature. As the author notes, this not only gives the reader access to detailed information, but it also emphasizes continuing developments in optics.

The book will be important to motion-picture and television engineers who have occasion to consult basic topics in optics. —*Pierre Mertz*, Bell Telephone Laboratories, 463 West St., New York 14.

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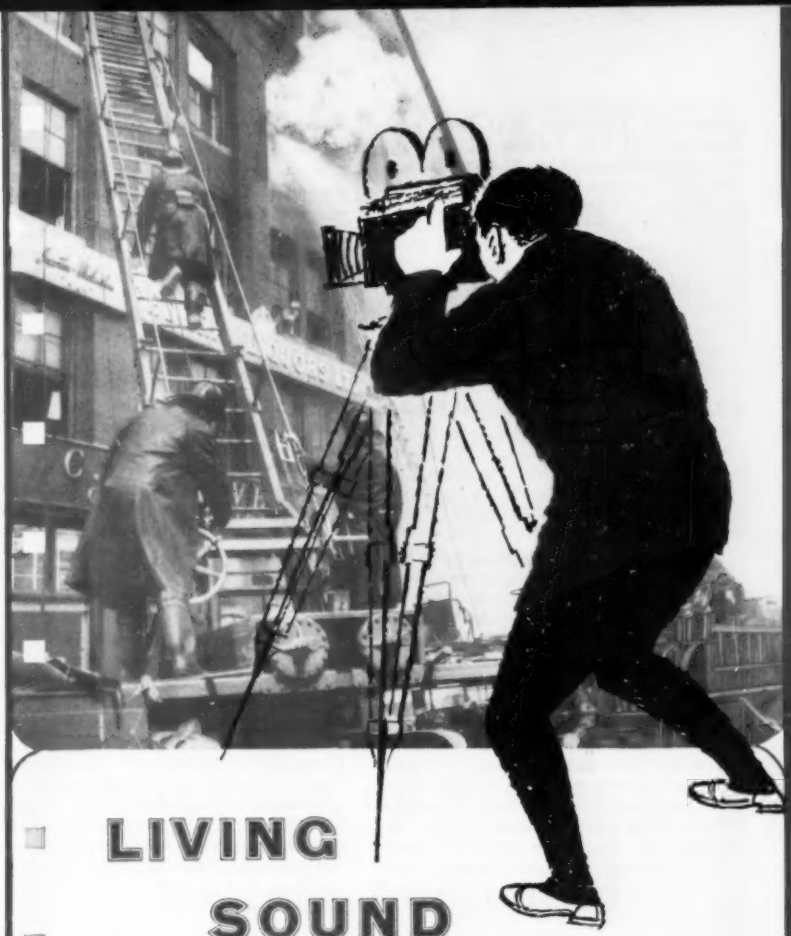

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Commercial Television Year Book and Directory. 2d Ed. Published (1957) by Business Publications Ltd., Mercury House, 109-119 Waterloo Rd., London, S.E. 1. 5¾ × 8¾ in. 272 pp. Price: $5.00. This reference book to British commercial television has been considerably enlarged since the first edition appeared. In addition to the usual directory listings of TV stations, advertising rates, etc., it now contains an artists' who's who, agents' addresses, a bibliography of television, and a number of special articles and maps.

Noise Control, a monthly periodical of the Acoustical Society of America, is being expanded in its field of coverage to include shock and vibration control. The Acoustical Society is a member society of the American Institute of Physics, 335 East 45 St., New York 17.

The new policy was inaugurated with the September issue which featured articles on vibration and shock, including an article by Dr. Walter Ramberg, Chief of the Mechanics Division, National Bureau of Standards. Subsequent issues will have discussions of devices and materials used to isolate vibration and articles on current problems in industrial and military installations.

The magazine, now in its third year is of special interest to engineers, architects and hygienists. Recent issues of the publication have considered noise problems in motion-picture, radio and television studios; in heating and ventilating and air-conditioning systems; industrial zoning and community noise and conservation of hearing in industry.

An index of RCA technical papers for the year 1956 is available upon request from Radio Corp. of America, RCA Laboratories, David Sarnoff Research Center, Princeton, N.J. The Index lists substantially all technical papers by RCA employees published during 1956. A limited number of indexes covering the years 1919–1945 (Vol. I), 1946–1950 (Vol. II) and 1951–1955 (Vol. III) are still available.

The Technical Book Co., 253 South Spring St., Los Angeles 12, has issued a "New Books" list of professional and scientific books, including publications in such scientific fields as communication and management; mathematics; electronics; electrical engineering; and radio and television are included. The list is available from the company upon request.

The American Society of Colleges for Teacher Education, 11 Elm St., Oneonta, N.Y. has issued a series of bulletins on *Television in Teacher Education*. Release No. 4 discusses "Points of View Regarding Television in Education." A statement by the Committee on Television of the American Council on Education warns against the extremes of an uncritical acceptance of television in education and the equally serious mistake of failing to explore its full possibilities as an educational tool.

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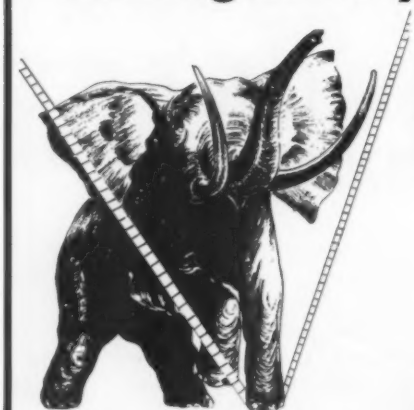

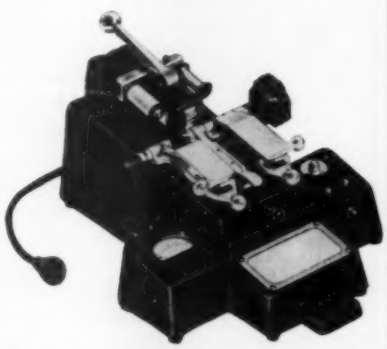

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Interscience Publishers, Inc., 250 Fifth Ave., New York 1, has been appointed exclusive, world-wide distributors for publications of the Microwave Research Institute of the Polytechnic Institute of Brooklyn. The publications include the Symposia Series, edited by Jerome Fox, and the two-volume *Handbook of Electronic Measurements*, reviewed in the July *Journal*, p. 442.

SMPTE Test Films

Test films planned by the Society's technical committees and produced under the Society's exact supervision are available from the headquarters office at 55 West 42 St., New York 36. Catalogs containing brief descriptions of each film are obtainable on request.

These films are used by manufacturers for testing the performance of new equipment, by television station technicians for lining up and adjusting film pickup systems, by maintenance men for "in service" maintenance of projectors and sound equipment, and by dealers for testing and demonstrating equipment.

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- Loudspeaker Phasing Test Film
- Constant Level Test Film
- Channel-Four Test Film
- Projector Alignment Chart
- Projector Alignment Chart (Optical Track) Standard Sprocket Holes

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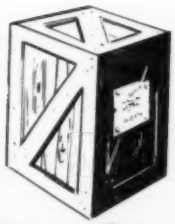
- Multifrequency Test Film
- Scanning-Beam Illumination Test Film
- Buzz-Track Test Film
- Sound-Focusing Test Film
- 400-Cycle Signal-Level Test Film

Picture Only — 16mm
- Registration Test Film
- Travel-Ghost Test Film

Glass Slide — 16mm
- Projector Lens Resolution Target



new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

MGM Camera 65

A system of photography using 65mm wide film has been developed by Metro-Goldwyn-Mayer Studio. The original photography is done on 65mm film, 5 sprocket holes per frame. Anamorphism is used in shooting the camera film, with a 1.33 to 1 squeeze ratio, resulting in a picture which has an angle of field with aspect ratio of exactly 3 to 1.

Release prints may be made by any of three methods:

(1) 65mm prints are made by direct contact from the negative, to be projected with a deanamorphosing projection lens, at a ratio of 1.33 to 1. It is expected that separate 6-track magnetic-striped film will be used for the sound for such prints. This method would be used for road-showing only.

(2) 70mm prints are made by contact printing from the 65mm negative which also requires a deanamorphosing projection lens at a ratio of 1.33 to 1 in order to unsqueeze the image. As in the case of the 65mm prints, there are six magnetic-striped tracks 100 mils wide.

(3) 35mm release prints are made by optical reduction from the 65mm negative, with 1.5 additional anamorphosis making a total anamorphism in the release print of 2 to 1 which is identical with that of CinemaScope. In developing this method, MGM aimed at a resultant CinemaScope-type print of superior quality. This type of print is to have sound in four magnetic stripes on CinemaScope-perforated 35mm film.

By means of an internegative CinemaScope-type prints are made from the original 65mm negative by direct reduction printing with added anamorphosis, through an internegative. The same end may be achieved by use of Technicolor dye-transfer process employing intermediate matrices.

Raintree County is the only picture thus far reported as made by this process, and the method used for release printing is not now known.

Calnatron, a method of electronic film recording designed for speed and economy, has been announced by California National Productions, Inc., 663 Fifth Ave., New York 22. The company is a subsidiary of National Broadcasting Co. The recording originates in a television studio where a master control board corrects the lighting. It is then transmitted to a receiver where it is photographed on special motion-picture film. One of the features of the system reported is the laboratory technique which effects speed and economy in film processing. Some of the suggested applications are for political speeches, executives' instruction to various branches of their organizations and for filming stage productions.

A group of five new static-magnetic regulators for stabilizing voltage supply to 6.3-v electron tube filaments is available from Sola Electric Co., 4633 W. 16 St., Chicago 50. The transformers are designed for simple mounting as product components, and take the place of conventional, unregulated filament transformers. Further information is contained in Bulletin CVF-269 available upon request from the company.

The Model CG 12 Current Governor is a two-terminal current stabilizer, modulator and electronic load, a new product of North Hills Electric Co., 402 Sagamore Ave., Mineola, N.Y. It is transistorized and features front panel control for selection of current levels in 50-ma steps from ½ to 30 amps. The stabilized current may be modulated 0–100% by external signals including sine wave, complex waveforms and d-c. Further information may be obtained by requesting Bulletin E 12 from the company. The company also offers a line of standard variable inductors and coil form assemblies designed especially for printed circuit application.

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A versatile panoramic camera for wide-angle aerial photography has been developed by the Perkin-Elmer Corp., Norwalk, Conn. Called the Model 501 Lightweight Tracking Camera, it is a scaled-down version of the 1500-lb Transverse Panoramic Camera designed for the Air Force. Weighing less than 53 lb fully loaded, it is 18 in. high, 3 ft long and slightly over 70mm in width. Operating on 28 v d-c power it contains built-in image motion compensator, intervalometer, an automatic exposure control and a wide range of scan rates and intervals.

The 501 also features high resolution of 40 lines/mm on high-speed film; automatic data recording; protection against stray light and humidity, and other safety features. The camera operates on a scanning principle and provides successive 180° panoramic photographs through the use of a rotating glass prism. There is no shutter, and exposures are made while moving the film over a slit in the camera. A few suggested applications are: military operations, geological survey work, aircraft altitude and velocity studies, and soil conservation studies.

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A group of panel devices which produce images electronically on flat panels has been developed by Sylvania Electric Products Inc., 1740 Broadway, New York 19. Known as Sylvatron, the process combines lighting and electronics. It is expected to have important applications in the fields of radar, air traffic control, instrumentation and other fields related to national defense or industry. The process is not, at the present time, applicable to consumer products.

The panels are electroluminescent glass or metal squares controlled by a photoconducting element which enables them not only to produce light, but also to produce images. Three basic types have been developed: (1) an electroluminescent panel on which the position of a mobile dot of light can be manipulated electrically; (2) a display panel which reproduces optically the track of a mobile spot of light (the image thus created can be held or "stored" indefinitely in visible form on the panel.); (3) an electroluminescent panel which can produce optically a motion picture with good resolution and rapid response. Further information, including a complete technical description, is available upon request from the company.

An automatic exposure control system that can be adapted for use with many still, aerial and motion-picture cameras has been announced by J. A. Maurer, Inc., 37–01 31st St., Long Island City, N.Y. Originally designed for use with the Maurer P-220 Aerial Reconnaissance Camera, the new system comprises a sensor,

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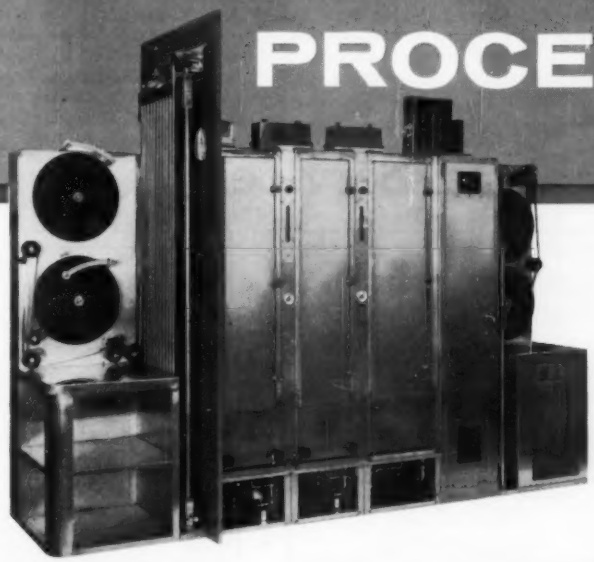

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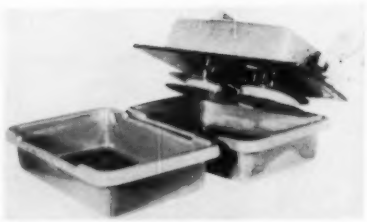
A new line of molded phenolic film rollers for 16mm and 35mm commercial film processing machines has been announced by J. A. Maurer, Inc., 37-01 31st St., Long Island City, N.Y. The rollers, designed to meet most Air Force environmental tests, feature sleeves and retaining rings of linen-base bakelite and glass ball-bearings encased in nylon bearing cages. The rollers are said to be unaffected by, and to have no deleterious effects on, processing solutions or films.



A developing tank with a capacity of 400 ft of 16mm or 35mm negative and positive film is announced by the Micro Record Corp., 487 South Ave., Beacon, N.Y. The new model D-31 is similar to the company's

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200-ft motor-driven tank. The tank can be operated in daylight after the film is loaded into the tank in a darkroom and covered with a light trap. The developing proceeds automatically until after the final washing when the operator removes the film from the tank and places it on the drying rack. Separate tanks are provided for each solution and a hose that can be secured to a water faucet is used for the final washing. Standard equipment includes the driving mechanism, light trap, one pair of 16mm or 35mm. reels, a length of hose with faucet adapter, three solution tanks and a wash tank. The developer is priced at $435 for 110-v a-c operation or $455 for 220-v.

The Scherr Micro Projector features a vertical principle of design which offers certain advantages such as a horizontal stage onto which flat-work can be placed without the use of holding devices; an inclined screen; and a choice of fixed standard magnifications that are changed by slipping different projection lenses into a vertical socket in which they rest by gravity. Custom-made precision coated lenses and achromatic condenser lenses are employed for different objectives 10 to 100 X magnification. The projector is priced at $395.00. An illustrated folder with a description of the projector and various accessories is available from George Scherr Co., 200 Lafayette St., New York 12.

Temperatures approaching the heat of the sun have been produced by the use of motion-picture equipment, according to a recent announcement by National Carbon Co., a Division of Union Carbide Corp. Two elliptical mirrors of the standard type used in motion-picture projection equipment are used. One mirror directs the energy of a carbon arc at the other, which in turn concentrates the radiation on the specimen being heated, forming a life-size image of the actual arc. Temperatures over 7000 F have been reached by this method.

Permafilm, Inc., New York 36, has announced the appointment of Sonocolor, S.A., of Paris, France, manufacturers of magnetic striping machinery and magnetic sound tape as its processor and agent for France and its colonies. Sonocolor has purchased Permafilm treatment equipment and will also package the product for the French trade.

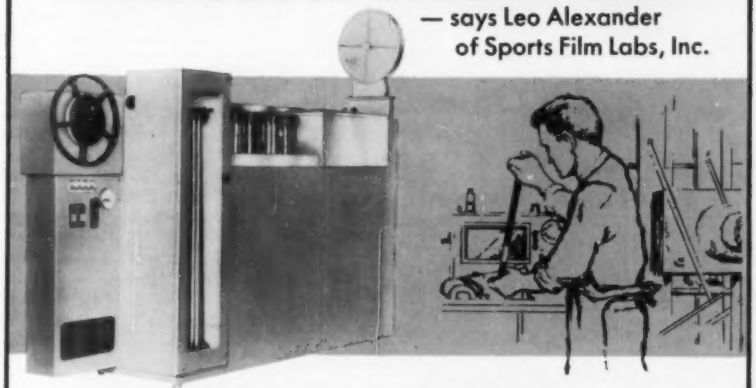
Scotch Brand Magnetic Tape No. 131 is a product of the Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn. Developed for professional use, it is reported to reduce print level by 8 db and to increase high-frequency response. It is packaged in a gray box marked "for professional use" and is identified by a gold "Low-Print" seal on the cover.

Gordon Enterprises, 5362 N. Cahuenga Blvd, North Hollywood, a rental agency specializing in motion-picture cameras and equipment, has added undersea cameras to its rental services. Among the undersea cameras that can be rented by the day, week or month is the Bathygraf 35mm camera developed by Capt. Jacques Yves Cousteau, producer of the motion picture, *The Silent World*. The firm also stocks the Bell & Howell Eyemo with Underwater Blimp.

A new Kodak Cine Ektar 50mm *f*/1.9 lens for the Kodak High Speed Camera is designed for middle-range, width-of-field coverage between the Kodak Cine Ektar 25mm lens (wide-angle) and the narrow-field 63mm lens. The new lens is available from Kodak Industrial and Audio-Visual Dealers.

"Our Filmline Processor gives us theater-quality footage automatically*— FREES US FOR OTHER WORK."

— says Leo Alexander of Sports Film Labs, Inc.



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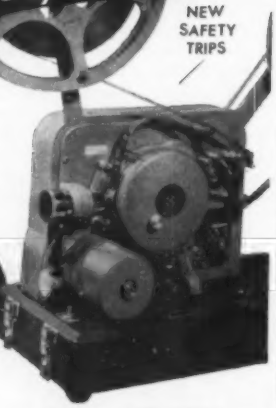

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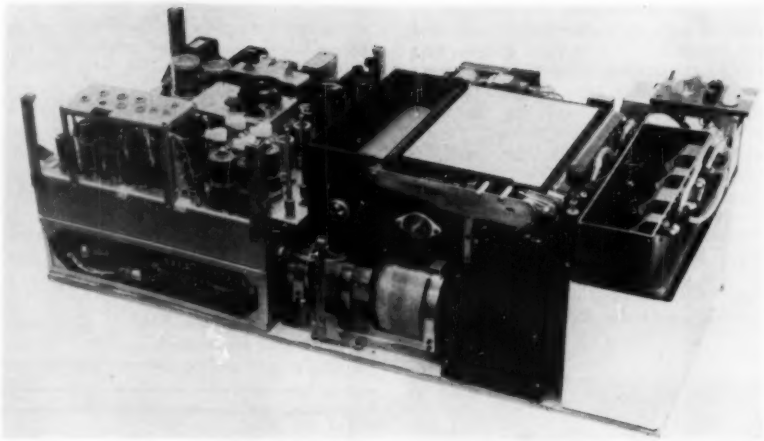

A radar strip recorder which photographs the ground beneath the airplane is a product of Hycon Mfg. Co., 1030 Arroyo Parkway, Pasadena, Calif. The recorder, designed for use with an airborne radar system, is also adaptable for ground use as a recorder of radar or telemeter information relayed from flying radar sets. It operates by making a photographic record of radar information on a slowly moving strip of film. The film, 9½ in. wide, is passed over a viewing screen so that the observer looks at a transparency 9 by 12 in. The film is slowly wound from one spool to another, making possible a permanent film record of the flight path of the airplane.

Beckman & Whitley, Inc., San Carlos, Calif., has divided its operations into two independent parts: Missile Products Div. and Instrument Div. Newly appointed manager of the Missile Products Div. is E. William Place, formerly product manager for missile devices. John C. Beckman, cofounder of the firm, is general manager of the Instrument Div. Activities of the Instrument Div. include research, development, manufacture and marketing of highly specialized meteorological equipment and high-speed research cameras.

Technicolor processing for 8mm and 16mm Kodachrome motion-picture film is now available to amateur photographers through its New York facilities as well as from its Hollywood laboratories. Services available from the New York plant include processing and duplicating 8mm and 16mm color motion-picture film; processing Anscochrome, Ektachrome and Kodachrome film; prints on an acetate-type base, Type "C" prints and dye transfer prints.

A Technical Counsel Service, headed by Paul Christman, has been announced by Byron, Inc., 1226 Wisconsin Ave., N.W., Washington 7, D.C. The new service will undertake to answer, in the field, questions arising in 16mm film production. Before accepting his present post, Mr. Christman was with the Ansco Division of General Aniline and Film Corp., and prior to his present appointment was Ansco's Eastern Regional Manager for Motion Picture Products.

General Films, Inc., P.O. Box 601, Princeton, N.J., a company that specializes in the production of 16mm films for churches, museums and schools, has expanded its activities to include the production of films on industrial and commercial subjects. The films, produced in professional 16mm color or black-and-white are planned especially for companies with medium-sized advertising budgets. The announcement was made by the company's president, Richard L. Hilliard. The company distributes films on a rental basis to cultural institutions and commercial organizations. Among its artistic productions are a 38-minute film of the medieval morality play, *Everyman*, and a 9-minute educational film, *Fall*.

Columbia Broadcasting System has announced plans for the construction of new laboratory facilities at Stamford, Conn. The one-story building will cover 33,000 sq. ft. and will provide research and development facilities for a scientific and administrative staff of 150 persons. Cost estimates are over $1 million. Construction of the new laboratory is a part of a program of expansion of research and development activies. Emphasis on research is in three areas: intensified search for new and improved audio and video techniques; broader development of electronics projects under government contract for military and other purposes; and more comprehensive applied research for industry.

The Oscar Fisher Co., Inc., has announced the removal of its manufacturing and office facilities from Peekskill, N.Y., to 5th Ave. and South Plank Rd., Md 27, Newburgh, N.Y. The firm has constructed a one-story steel and concrete building to house expanded engineering, manufacturing and office facilities. New production equipment has been installed.

A glossary of 99 high fidelity and tape-recording terms has been prepared by Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn. The glossary is intended primarily for amateur and church and school users, but may be helpful to professional users. It is available from the company upon request.

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The Bolex Adapter Ring for connecting 16mm extension tubes to all 8mm motion-picture cameras with standard ASA "D" mounts is distributed by Paillard, Inc., 100 Sixth Ave., New York 13. The tubes and adapters are sold as a boxed set at $14.00. The set consists of the special adapter No. 4, which mounts the 16mm tubes to any 8mm camera with a standard "D" mount; a No. I 16mm extension tube and a No. II 16mm extension tube, plus the standard 16mm-to-8mm adapter for connecting the 8mm lenses to the 16mm tubes.

Journals Available

These notices are published as a service to expedite disposal and acquisition of out-of-print Journals. Please write direct to the persons and addresses listed.

Issues beginning in 1953 available on a nominal basis. Write: Mitchell M. Badler, 1711 Davidson Ave., Bronx 53, N.Y.

Recent issues available. Write: F. H. Cole, 144 Via Trieste, Newport Beach, Calif.

Jan. 1930 through Dec. 1937; Journal SMPE issues; and Jan. 1930 through Dec. 1935, bound volumes of SMPE Journal; SMPE Transactions: Apr. 1919:8, May 1920:10; May 1922:13; Oct. 1922:15; May 1925:21; Oct. 1925:24; Apr. 1927:30; Sept. 1927:32; Apr. 1928:33; Sept. 1928:36; SMPE Membership Listings: 1928, 1930, 1938; SMPE Index and Authors: 1930–1935; SMPE Miscellaneous: ASA Z22—1930; Dim Stab of M.P. Films 1934; ASA Z22—1935; High Intensity Lamps—1935; Program Spring Convention Apr. 26, 1939. Write John Faber, 5 Edgewater Drive, Denville, N. J. Phone Rockaway 9-2623M.

Complete set of Journals from May 1937 to June 1954, including special volumes and membership directories, excellent condition; also Mar., May 1934 and July 1935 issues. Write: Harry R. Lubcke, 2443 Creston Way, Hollywood 28, Calif. HO 9-3266.

Jan.–Dec. 1950; Jan., Feb., Apr.–Dec. 1951; Jan.–Mar. 1952. Also available are vols. 6 and 7 of the The Television Society (British) covering the period Jan. 1950 through Sept. 1955. Write: Andrew N. McClellan, 65 Hillside Drive, Toronto 6, Ont., Canada.

July–Dec. 1952, Jan.–Nov. 1953, Jan.–Apr., June–July, Sept.–Dec. 1954, Jan.–Mar. 1955. Write: Omar Marcus, 1925 Cadiz St., New Orleans 15, La.

Dec. 1946, Feb.–Dec. 1947, 1948–1955 complete. All copies in perfect condition; for sale as entire lot only. Write: Joseph W. MacDonald, 2414 Sullivant Ave., Columbus 4, Ohio.

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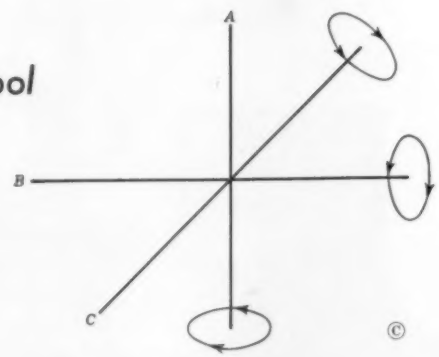

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These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Film Writer-Editor, with directorial experience, now engaged in post-graduate work at City College Institute of Film Techniques. Three years experience in direction of off-Broadway theater. Has written scripts for NBC-TV and industrial films. Experienced with all 16mm cameras and editing equipment. Formerly with Screen Gems, Inc. Willing to relocate. Write: Lawrence G. Cohen, 55 Nagle Ave., New York 40.

Producer-Director-Cinematographer. Comprehensive background in all phases of motion-picture production: creative, technical and artistic. More than 13 years in motion-picture, live-television and radio production. Independent producer 6 years. Experience also includes writing, editing, acting and narration. Very fluent Spanish including technical terms. Desires position with production company or in motion-picture department of large industrial corporation. Interested in the United States, Central or South America. Résumé available in English or Spanish. Write: Oliver E. Cain, P.O. Box 1594, Amarillo, Texas.

Studio Technician. Young man (27), Recent graduate of TV Workshop, finished in top three of class; thoroughly qualified audio engineer, TV cameraman, floor manager, video operator, dolly and boom operator, etc., with knowledge of scenery, special effects, lighting, color TV principles and operations. Seeking job in TV production. Willing to relocate anywhere (Timbuktu if necessary); will accept modest salary to start. Arthur K. Hirshman, 2242 Bragg St., Brooklyn 29, N.Y. Tel: NIghtingale 6-3997.

Motion-Picture Development Engineering. Thoroughly familiar with design, construction and installation of motion-picture film processors and allied laboratory equipment. Scope of 12 yr of laboratory experience ranges from maintenance to plant engineering. Also additional mechanical and refrigeration background. Resumé on request. Apartment 7-B, 283 Avenue C, New York 9. Tel: ORegon 4-8165.

Research or Sales. College graduate with degree in photography and background in engineering desires position in research or sales. Contact George Daugherty, 7413 Heather Row Lane, Houston, Texas.

Stereoscopy. Seeking opportunity for research and development work in phases of motion-pictures and television leading to an accurate reproduction of the illusion of life such as stereoscopic sight (unaided), binaural sound, smell, etc. Have done independent research for 10 yr and prepared book on integrated high-speed stereo. Robert B. Collender, 58 Van Reipen Ave., Jersey City, N. J.

Audio-Visual Supervisor. Master's degree in education, specializing in production of audio-visual materials. AB in English. Experience in educational television production, planning and production of industrial films. Former audio-visual supervisor for guided missile manufac-

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turer, heading motion-pictures and military presentations. Now engaged in educational film production. Will consider educational or industrial work. Age 32; married. Larry J. Beck, 4303 South 7th St., Tacoma, Wash. Tel: SK 23056.

Sales Representative. Experienced, mature, versatile (editing, cinematography, recording, scripting), supervisory and administrative ability. Former active producer; kinescope recording experience; capable of sales representation on top agency and client level. Excellent references; free to travel and relocate; married; age 34; 15 yr active film experience. Write: c/o Artz, 1365 York Ave., New York 21.

Cinematographer-Photographer. Six yr professional experience in all phases photography, motion-picture, still, color, film editing and production. Two yr photo and cinema school. Presently working as plant photographer in large industrial plant. Age 26, single, will relocate. Desires TV, industrial or production work. Résumé on request. Write: I. Mann, 1123 West Pratt Blvd., Chicago 26.

Motion-Picture Cameraman. Well rounded background in every phase of motion-picture photography, including 3 years as cameraman with leading university. Desire to become affiliated with stable film unit. Married. Age 31. Free to travel. Write: John Viazanko, 1207 Krameria St., Denver 20, Colo.

Positions Available

Motion-Picture Development Engineer. Mechanical engineer or equiv. required by long-established motion-picture developing machine concern. Must be thoroughly familiar with machine design and construction and capable of supervising projects through manufacturing processes. Technical knowledge of color and spray processes desirable. Salary open. Send resume with references and salary requirements to: Filmline Corp., 43 Erna Ave., Milford, Conn.

Arriflex Specialist. Position open for bright, ambitious, salesminded young man to become Arriflex specialist in our growing organization. Must have at least 3 yr experience in professional motion-picture equipment, 16 and 35mm. Excellent working conditions in creative atmosphere and attractive earnings in progressive organization. Send hand-written application and resumé in confidence to Paul Klingenstein, Pres., Kling Photo Corp., 257 Fourth Ave., New York 10.

Film Library Supervisor. $5280–$6460/yr. Requirements: Minimum qualifications: Graduation from a standard senior high school or possession of a high-school equivalency diploma. Minimum experience: One year of satisfactory experience in reviewing, evaluating, maintaining and planning for the distribution of motion-picture film, and in addition any one of the following: Four more years of experience; graduation from a recognized college or university from a 4-year course for which a bachelor's degree is granted with specialization in radio, television and motion-picture production or a satisfactory equivalent combination of the foregoing training and experience. Applications for examination will be accepted through Sept. 20 at the New York State Dep't of Civil Service, State Office Building, Albany, N.Y.

Photographic Engineers. GS-11; $6390/yr; requiremeuts: engineering degree plus 2½ yr general engineering experience including 1 yr specialized experience in the photographic field. GS-12; $7570/yr; requirements: engineering degree plus 3½ yr general engineering experience including 1 yr experience in the photographic field. GS-13; $8990/yr; requirements: engineering degree plus 4 yr general engineering and administrative experience including 1 yr specialized experience in the photographic field. Contact Civilian Personnel Office, Employee Utilization Div., Bldg. 787, Fort Monmouth, N.J., as soon as possible. All positions will be located in vicinity of Fort Monmouth, with a minor amount of travel involved.

The U. S. Civil Service Commission has revised and reissued the announcement of the currently open examination for engineer. The new announcement incorporates examinations for various specialized branches of engineering formerly publicized in separate announcements. Pay for various positions ranges from $4,480 to $11,610 a year. For further information consult Civil Service Examination Announcement No. 112 B obtainable from most post offices or from the U. S. Civil Service Commission, Washington 25, D.C.

The Federal Government now employs about 50,000 engineers and is asking for many more engineers in all specialized fields. U. S. Civil Service Commission Announcement No. 112B reports on open examinations for positions at salaries ranging from $4,480 to $11,610 yearly. About 10,000 engineers are employed in the Washington, D.C. area and more than 30 Federal agencies make use of their services. Other positions exist throughout the United States and the world. Additional information is available from the Executive Secretary, Board of U.S. Civil Service Examiners, Washington 25, D.C.

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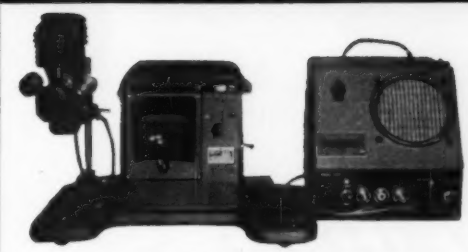

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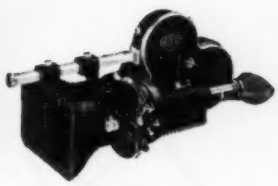

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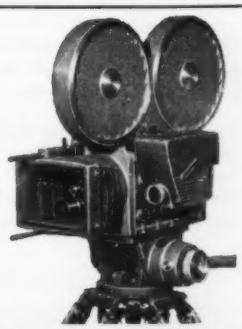

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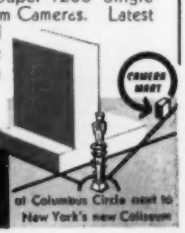

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Contents — pages 635 - 660

News Columns

Telemovies—Bartlesville, Okla. 635
Education, Industry News 638
Obituary: Donald MacKenzie 641
Current Literature 641
BOOKS REVIEWED 643

Proceedings of the Third International Congress on High-Speed Photography edited by R. B. Collins, reviewed by Carlos Elmer; *Selling Color to People* by Faber Birren, reviewed by Wilton R. Holm; *Proceedings of the National Electronics Conference Volume 12*, reviewed by S. Sherr; *The Lion's Share* by Bosley Crowther; *Responsibilities of Film Producers and Sponsors; Magnetic Recording Handbook* by R. E. B. Hickman, reviewed by Marvin Camras; *Agfa Magnetic Tape, Its Application and Testing* by K. A. Mittelstrass, reviewed by Marvin Camras; *Technisches Kinotaschenbuch; Lexikon der Kinotechnik* by Alfred R. Schulze; *Cinematheque de Belgique; 1957 Film Daily Year Book; Fundamentals of Optics* (3d ed.) by Francis A. Jenkins and Harvey E. White, reviewed by Pierre Mertz.

New Products 651
Journals Available 658
Employment Service 658

Advertisers

Berndt-Bach, Inc. 645
Camera Equipment Co. 640, 641
Camera Mart, Inc. 659
D'Arcy Magnetic Products, Inc. 658
Daven Co. 648
Eastern Film Laboratories 652
Filmline Corp. 655
Harwald Co. 656
Hollywood Film Co. 637
Houston Fearless 653
Philip A. Hunt Co. 644
Kling Photo Corp. 638, 660
Magnasync Mfg. Co., Ltd. 639
Motion Picture Laboratories, Inc. 648
Movielab Color Corp. 657
Peerless Film Processing Corp. 651
Photo Research Corp. 646
Precision Film Laboratories, Inc. 647
Precision Laboratories 642
Prestoseal Mfg. Co. 650
Professional Services 654
Reeves Soundcraft Corp. 649
Westrex Corp. 643

Meeting Calendar

Acoustical Society of America, National Meeting, Oct. 24–26, Univ. of Michigan, Ann Arbor, Mich.

American Standards Association, Eighth National Conference on Standards, Nov. 13–15, San Francisco.

IRE, ASQC, AIEE, RETMA, Fourth National Symposium on Reliability and Quality Control, Jan. 6–8, 1958, Hotel Statler, Washington, D. C.

83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21–26, 1958, Ambassador Hotel, Los Angeles.

Fourth International Congress on High-Speed Photography, including Equipment Exhibit, Sept. 22–27, 1958, Cologne.

84th Semiannual Convention of the SMPTE, Oct. 20–24, 1958, Sheraton-Cadillac, Detroit.

American Standards Association, Ninth National Conference on Standards, Nov. 18–20, 1958, Hotel Roosevelt, New York.

85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4–8, 1959, Fontainebleau, Miami Beach.

86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 5–9, 1959, Statler, New York.

87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles.

88th Semiannual Convention of the SMPTE, Fall, 1960, Shoreham Hotel, Washington, D. C.

89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.

90th Semiannual Convention of the SMPTE, Oct. 15–20, 1961, Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1957 Journal.

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Century Lighting, Inc.
Century Projector Corporation
Cineffects, Inc.
Cinema-Tirage L. Maurice
Geo. W. Colburn Laboratory, Inc.
Comprehensive Service Corporation
Consolidated Film Industries
DeFrenes Company
Andre Debrie Mfg. Corp.
DeLuxe Laboratories, Inc.
Desilu Productions, Inc.
Dominion Sound Equipments Limited
Du Art Laboratories, Inc.
E. I. du Pont de Nemours & Co., Inc.
Dynamic Films, Inc.
Eastman Kodak Company
Elgeet Optical Company, Inc.
Max Factor & Co.
Fordel Films, Inc.
General Electric Company
General Film Laboratories Corporation
General Motors Photographic
General Precision Equipment Corp.
  Ampro Corporation
  Askania Regulator Company
  General Precision Laboratory Incorporated
  The Hertner Electric Company
  International Projector Corporation
  J. E. McAuley Mfg. Co.
  National Theatre Supply
  The Strong Electric Company
W. J. German, Inc.
Guffanti Film Laboratories, Inc.
Hollywood Film Company
Houston Fearless
Hunt's Theatres
Hurley Screen Company, Inc.
JM Developments, Inc.
The Jam Handy Organization, Inc.
Jamieson Film Co.
Kalart Co.
KINTEL (Kay Lab)
Kling Photo Corp. (ARRI Div.)
Kollmorgen Optical Corporation
Lorraine Carbons
J. A. Maurer, Inc.
  Precision Film Laboratories, Inc.
Mecca Film Laboratories, Inc.
Mitchell Camera Corporation
Mole-Richardson Co.
Motiograph, Inc.
Motion Picture Association of America, Inc.
  Allied Artists Products, Inc.
  Columbia Pictures Corporation
  Loew's Inc.
  Paramount Pictures Corporation
  RKO Radio Pictures, Inc.
  Republic Pictures Corp.
  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, A Division of Union Carbide and Carbon Corporation
National Screen Service Corporation
National Theatre Amusement Co.
Neighborhood Theatre, Inc.
Neumade Products Corp.
Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Polaroid Corporation
Producers Service Co.
Projection Optics Co., Inc.
Radiant Manufacturing Corporation
Radio Corporation of America
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
Charles Ross, Inc.
S.O.S. Cinema Supply Corp.
SRT Television Studios
Shelly Films Limited (Canada)
Technicolor Corporation
Titra Film Laboratories, Inc.
Van Praag Productions
Victor Animatograph Corp.
Alexander F. Victor Enterprises, Inc.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company